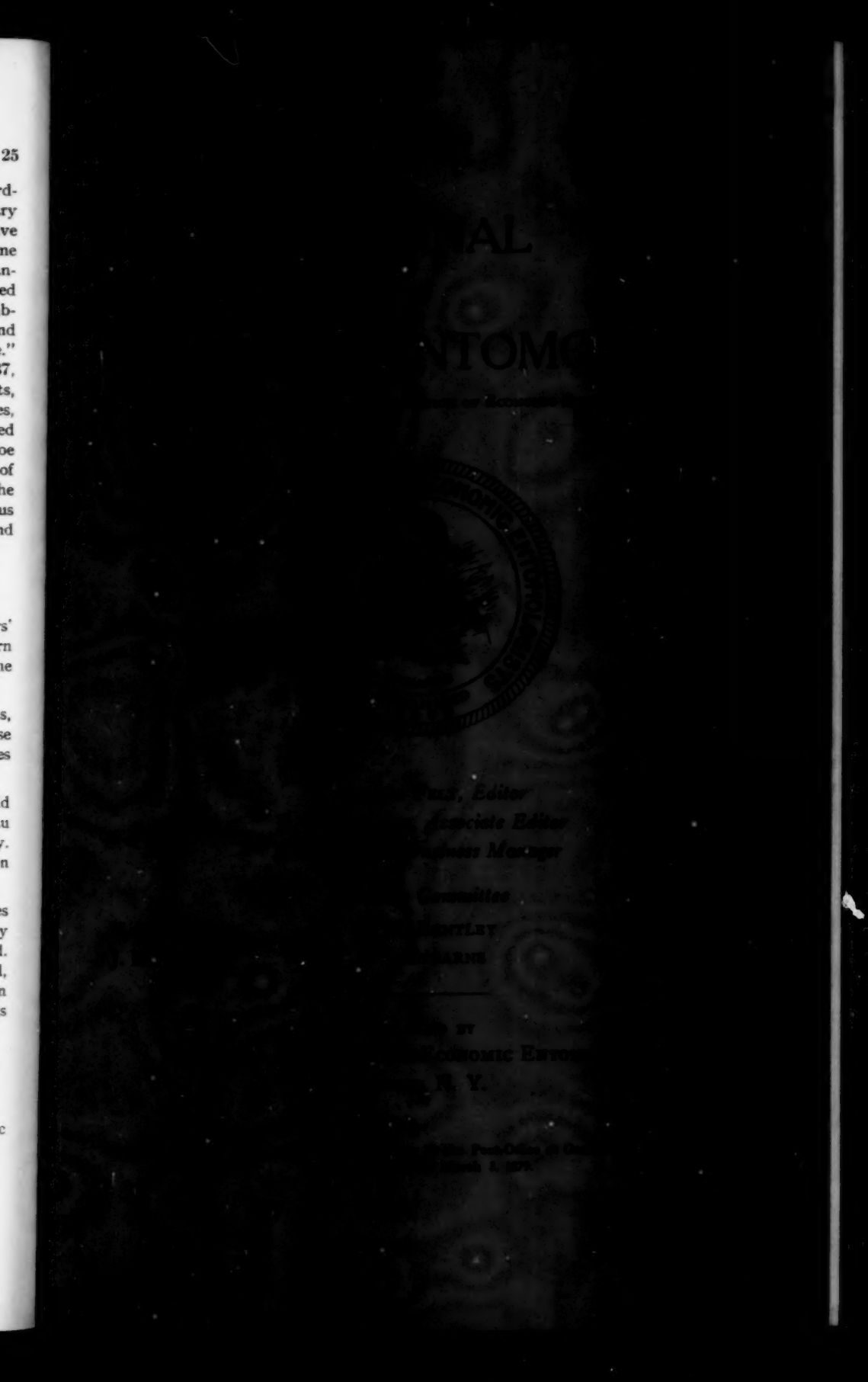

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American Association of Economic Entomologists
Section of Plant Quarantine and Inspection

Session Tuesday afternoon, December 29, 1931

Chairman K. C. Sullivan called the meeting to order and appointed the following committees:

Nominations: J. M. Bentley, A. G. Ruggles, and A. C. Fleury.

Resolutions: J. H. Montgomery, W. A. Price and G. A. Dean.

Officers elected, were: Chairman, W. A. Price; Secretary, S. B. Fracker.

SOME REGULATORY PROBLEMS

By K. C. SULLIVAN, *Jefferson City, Mo.*

ABSTRACT

A brief discussion of some of the problems confronting regulatory officials at the present time, calling attention to the transportation of plants and plant materials by unregulated trucks over Federal-State highways; the use of clean planting stock in highway beautification projects; financing of regulatory services under present economic conditions and quarantines.

Since the inception of regulatory work as a means of combating and preventing the spread of injurious insect pests and plant diseases, a surprising amount of progress has been made, and much good has been accomplished. It would be impossible to estimate the saving to American agriculture brought about by the establishment of plant quarantine and regulatory measures. It is unfortunate that regulatory measures were not enacted and placed in operation at an earlier date.

At the present time, no one can justly question the value of sane regulatory measures, judiciously enforced. The support, financial and otherwise, which regulatory work is receiving at the present time, not only from the Federal and State governments, but from more local units is sufficient to convince the most skeptical of its value and success.

The importance of regulatory work in preventing the spread of dangerous insect pests and plant diseases must of necessity continue to develop, and it must continue to receive sufficient support to enable those in charge to render the maximum of service.

Only a few years ago, an individual collecting insects with a "bug" net was looked upon as a person somewhat out of the ordinary, possessing some kind of a queer twist in his mental makeup. At the present time, however, most everyone appreciates the efforts which the entomologist and the plant pathologist are putting forth in their efforts to eliminate and check the ravages of insect pests and plant diseases. This change in attitude of the general public has (without question) been due to a very great extent, to the untiring efforts which regulatory officials have put forth so patiently and successfully.

The simple fact that a regulatory official is clothed with police power may be helpful at times, and, under certain conditions, a judicious utilization of this power is fully justified. It is a useful and valuable instrument as a last resort. It has not been this police power, however, that has brought regulatory work into the high regard which it enjoys today. It has been the service to mankind in helping to prevent further injury and loss to the products of labor, by insects and diseases; the way in which this work has been administered; and the results which have been obtained. Regulatory officials have no difficulty in obtaining the cooperation and loyal support of the people with whom they work.

The thing that makes any type of work interesting is the new problems that are constantly developing, and this is particularly true of regulatory work. The individual who is engaged in strictly research work naturally has problems, also, and one problem may lead to another and he may derive a great deal of pleasure and satisfaction in working out the solution. The same may be said of teaching, but it is doubtful if either will compare with the great variety of problems which are constantly developing for the regulatory official. Naturally, many of their problems are of a scientific nature, which requires careful scientific investigation; some are legal in character; others require careful diplomatic manipulation to bring about a satisfactory solution, and still others may tend to the political. In the end, however, they all must be combined and worked out in such a way that practical and beneficial results are obtained.

The rapid advance which civilization is making at the present time constantly presents new and complicated problems which regulatory officials must face. Some of these problems are extremely difficult, though to the uninitiated they may seem simple and easy of solution.

Probably one of the most serious problems that has developed out of our present complicated method of living is one due to the construction of good roads. There is hardly a community that is not connected with the more important centers with a hard surfaced road; passable twelve months of the year. This great network of highways throughout the land has accomplished wonders. The hard surfaced roads have opened up new fields of endeavor; they have brought more people in contact with each other; they have created a new era in transportation; and they have put the motor truck in real competition with the other common carriers.

With the beginning of regulatory laws and regulations, the common carriers, like the railroad, were the first to be called upon to cooperate in carrying out the intentions of the regulations. At the present time, when a new regulation goes into force, the railroads are the first to comply with the regulation, and this fine cooperation has meant a great deal to the success of regulatory work in general.

Every regulatory official realizes the serious problem presented by the increased transportation by motor trucks. This mode of transportation has developed rapidly and is continuing to develop by leaps and bounds. In some cases companies have been formed which operate large numbers of trucks and are reliable, honest, and dependable. It is a fact, however, that the majority of products transported by motor truck (and these products include everything) are hauled by individuals who operate seldom more than one truck, and ofttimes it has been bought on the installment plan and is not yet paid for. These concerns or individuals pay no attention whatever to state lines, but traverse the country from one end to the other transporting anything that happens to be at hand and in most cases entirely disregarding any and all laws or regulations which may be in effect.

Probably every regulatory official is facing the serious problem which motor transportation has brought about in regulating the transportation and distribution of plants and plant parts which might carry dangerous insects and plant diseases. No one can doubt the seriousness of the situation. It is not difficult to cite specific examples where quantities of plant material or plant products have been transported half-way across the continent by motor truck. No one knows what dangerous insect pests or plant diseases these products might carry.

Of necessity, freight, express and mail shipments pass through terminals, and in these terminals it is not a very difficult task for a regulatory official to check the shipments as they pass through. On the other hand, a shipment by motor truck may be picked up at any given

point and then delivered directly to the consumer, with little or no opportunity for a regulatory official to check in any way the materials or products being transported.

The problem of regulating motor trucks engaged in the transportation of all kinds of products is a difficult one. However, some progress is being made. In my own state, Missouri, a law has just gone into effect requiring all individuals engaged in the business of hauling products by motor truck to register with the Public Service Commission. This registration carries what seems to be an adequate registration fee. This law, we hope, will help in bringing under control the transportation of plants and plant parts.

The transportation of products by motor truck will, without question, continue to increase, both inter and intrastate, and in order to bring this type of transportation under control both federal and state legislation will be necessary.

The construction of permanently maintained highways has brought forth systems and plans of highway beautification calling for the use of large quantities of plant materials, especially ornamental shrubs and trees. In many cases highway departments and officials have sponsored and encouraged local organizations, state, county and city, to take over highway beautification projects, and a great deal of progress has already been made. This is worth while work, and should be continued and encouraged.

It so happens that the training of most highway officials has been along engineering lines. Their horticultural, entomological and plant pathological training has, unfortunately, been somewhat neglected. It is doubtful if they fully realize the importance of obtaining clean planting stock in the beginning, and the additional importance of keeping the plantings clean through proper care later on.

In some instances it has been recommended that organizations interested in highway beautification obtain as much of the planting stock as possible from the forest or any other source where it may be gotten at little or no cost, and then to plant it along the public highway regardless of any insect pest or plant disease it may harbor. It is quite a temptation, for example, for a perfectly well meaning organization to obtain cedar trees from the forest and plant them along the highway in close proximity or even adjacent to an apple orchard, being totally ignorant of the fact that the cedar is a necessary host of cedar rust of apple.

In most cases those highway officials having charge of plantings and highway beautification plans, will be found willing to cooperate with

regulatory officials to such an extent that only suitable and clean stock will be planted.

Due to the fact that the first regulatory laws having to do with the plants and plant parts were enacted as a result of an invasion of an insect pest, the regulatory work at this time is largely controlled and administered by entomologists. This probably is as it should be. However, it should not be forgotten that some of our plant diseases are just as important as are some of our insect pests. It is also true that few of our entomologists are as thoroughly trained in plant pathological work as they are in entomological work. Even though this may be true, the plant diseases should be given due consideration. Wherever possible a regulatory service, in order to bring about the best results should be well balanced, with not only well trained entomologists, but also well trained plant pathologists.

In most institutions where scientific training is given to students, both entomological and plant pathological courses are available. In selecting inspectors, it is highly desirable that their training in both of these important sciences be fairly well balanced.

In many states at the present time, the question of financing regulatory work has developed into one of primary importance. From the standpoint of regulatory officials, probably the ideal way of financing the work is by direct appropriations from the state revenues. There seems to be developing, however, at the present time, the idea that an industry directly benefited or served should support the service if not in whole, at least in part. In most cases, however, it would be putting too much of a burden—for example, to ask the nursery industry to support all of the inspection or regulatory work. Also, it is doubtful if such a procedure would be justified. Although the nursery industry may be directly served and probably benefits more than any other industry, nevertheless, every individual who obtains a tree or plant from an inspected nursery derives a benefit from the inspection service. For this reason, it is perfectly wise and proper to solicit support from revenue derived by taxation.

There is also ample justification for the utilization of funds derived directly from the industry, through a system of fees or the sale of inspection tags. Funds derived through a fee system may, at times, be of great importance, especially with conditions as they are at the present. There may be times when it is difficult to obtain an appropriation.

A nominal fee, charged for the inspection of a premise, may serve a valuable purpose in another way, in that only those individuals who actually have plants or plant materials for sale request the service.

In my own state, for example, a fee is collected for each inspection made. If it were not for this fee, it would be impossible to take care of the request for inspections without greatly increasing the inspection force—and the probabilities are that very few more plants or plant parts would be offered for sale than are offered at the present time.

There is a grave possibility, especially if the present economic conditions continue for a great while longer, that future legislative bodies will insist on a program that calls for rigid economy. This is proper, and no one will object, providing the economizing is applied in a just and equitable manner.

Agriculture, being the basic industry underlying our economic existence, must not be allowed to suffer through any unwise legislative program. An efficient regulatory service having to do with the control and regulation of insect pests and plant diseases is absolutely essential. Such a service should and must receive legislative support. It may be a good policy, however, to supplement such support by having some income which may be derived from a system of fees.

The question of quarantines is one that has been given much thought by many of our most competent and best trained specialists. Much good has been and still is being accomplished by the application and enforcement of quarantine measures. A quarantine is a valuable instrument, when justly and sanely applied. In general, however, when the enforcement and maintenance of a quarantine costs more than the value which is, or may be derived; taking into consideration the various economic factors, then that particular quarantine should be abolished. No quarantine should be promulgated, unless the good which will be derived will fully off-set any losses that it may cause.

It seems likely that the application of quarantines will become more complicated, as time goes on. It is essential that the greatest of care be exercised in their promulgation and administration.

In general, the growth and development of regulatory work has been steady. The value of regulatory work, in preventing the spread of dangerous insect pests and plant diseases, has proved worth while. The individuals, who (in the beginning) gave their time and effort in laying the foundation and building a strong and substantial structure, deserve the commendation of a grateful people. May we continue to build and to render a service that will be lasting and worthy of the the cause in which we are engaged.

OZONIUM ROOT-ROT—A PROBLEM OF THE ERADICATION OF A SOIL-INFECTING FUNGUS

By K. F. KELLERMAN, *Associate Chief, Bureau of Plant Industry, U. S. D. A., Washington, D. C.*

For many years cotton root-rot was recognized as a very serious disease of cotton especially in Texas but it caused losses also in New Mexico and Arizona. While scattered infections in the Colorado River Basin were known to exist in California, no infections in the interior or western portion of the State had ever been located until the disease was discovered on the grounds of the date experiment station at Indio, California, the most western point in which the disease has ever been recorded. The discovery was of exceptional seriousness to the State of California, since this disease is highly destructive to deciduous fruit trees, and if the disease should become widely established in the deciduous fruit regions of California it would be difficult to estimate the damage that would ensue.

A special appropriation of $25,000 became available for this work in the spring of 1930. Vigorous efforts at checking the spread of the fungus in the soil were undertaken by digging deep trenches and backfilling with mixtures of earth and crude oil. While this was presumed to be a temporary safeguard, it was clear that it could not serve as a permanent barrier to the spread of the fungus, and thorough-going disinfection of the soil by the use of dilute formalin was decided upon after consultation with Dr. D. G. Milbrath, of the California State Department of Agriculture.

Dr. Milbrath suggested the feasibility of employing a specially constructed treating tube in connection with a power spray rig for injecting formalin at considerable depths into the soil substantially in accordance with the technique originated by L. R. McKinnon and Omund Lilleland, of the University of California, for application of water fertilizers (Soil Science, Vol. XXXI, No. 5, May, 1931.—A method of application designed to insure proper distribution of fertilizers in field trials with fruit trees.) After some experimentation with the type of tubes and nozzles that would be most satisfactory for this purpose, substantially the same apparatus, using two tubes joined at the base 1 foot apart thus permitting the application of the formalin through two nozzles 1 foot apart and for approximately a depth of 6 feet, was employed in place of the spray nozzles with a modern high-pressure sprayer.

As an area of five acres within the date garden was known to be infected, the application of disinfectants was an engineering feat of con-

siderable magnitude. A 1¼ per cent solution of formalin was distributed under high pressure in the soil through pointed nozzles at the ends of galvanized pipe tubes approximately 6 feet in length. These were attached to modern high-pressure spray pumps and they functioned as miniature hydraulic boring machines and in this way it was easy to distribute the formalin to a depth of 6 feet throughout the entire 5-acre area. The miniature boring points were inserted every foot in each direction throughout this area and approximately 1 gallon of solution per cubic foot of soil was applied at each insertion.

For convenience and accuracy in applying the solution a platform with holes bored at 12-inch intervals in each direction was used for a treating platform, the treating tubes being inserted through the holes in the platform and into the soil. This facilitated accuracy of treatment and also served to better control the formalin which otherwise frequently boiled up in a somewhat troublesome manner around the side of the treating tubes. In all, almost one and one-third million gallons of the dilute formalin solution were applied to the area.

This work was under the immediate direction of Mr. Frank A. Thackery, of the Bureau of Plant Industry, who received favorable cooperative assistance from Dr. D. G. Milbrath and others of the California State Department of Agriculture.

Dr. D. G. Milbrath, Mr. Frank A. Thackery, and Mr. C. J. King (who is carrying on special studies of the life history and methods of control of the root-rot fungus in Arizona) have made examination at frequent intervals since treatment of this area and, while mycelium and sclerotia of the root-rot fungus have been found, in all cases the fungus has been found to be dead as the result of the formalin treatment. The treatment also destroyed practically all seeds of living plants within the area. It is believed that complete eradication was secured by this treatment. The formalin introduced into the soil has disappeared it is believed, but no planting has been undertaken in the treated area. Planting experiments are contemplated during the coming season.

PLANT QUARANTINE SERVICE IN PORTO RICO

By RICHARD FAXON and CLYDE P. TROTTER, *Plant Quarantine and Control Administration, U. S. D. A.*

ABSTRACT

A comprehensive, historical account of the plant quarantine service.

The present plant quarantine activities in Porto Rico are of peculiar interest since they involve the enforcement of Federal foreign and domestic plant quarantines as well as certain Insular quarantines. Since little information is available with respect to the plant quarantine work which has been performed in Porto Rico to date, it seems advisable to discuss not only the present restrictions but to review the early activities along this line as well.[1]

The Island of Porto Rico is the smallest and most eastern of the Greater Antilles, which are the largest group of islands in the West Indies. It is about 100 miles long from east to west and about 35 miles wide. It is quite mountainous in the central portion, some of the ranges reaching 3,000 to 4,000 feet in elevation. A great variety of crops can be produced on the Island, including most of the tropical and subtropical crops. At present sugar cane, coffee, tobacco, citrus fruit, and cotton are the most important crops, while the amount of winter vegetables being raised for the New York market is increasing.

With its location in the Tropics the Island offers a favorable opportunity for the introduction and establishment of many injurious insects and plant diseases existing in neighboring islands and in other foreign countries. The experience of some of these islands and foreign countries with pests brought in with unregulated imports of plant materials was well known, and previous to 1910 host fruits of the Mediterranean fruit fly from Spain were freely imported into Porto Rico so that the movement for a plant-quarantine law was generally supported by the agricultural interests of the Island.

As the Insular law antedates that of the Federal Plant Quarantine Act by nearly two years its early application and those who administered it are of considerable interest. J. T. Crawley, Director and D. L. Van Dine, Entomologist of the Sugar Producers Experiment Station at

[1]The historical notes are principally from Annual Reports of the Board of Commissioners of Agriculture and Governors of Porto Rico, Bulletin No. 23, Insular Experiment Station, by E. G. Smyth, and Annual Reports of the Plant Quarantine Service, furnished through the courtesy of L. A. Catoni, Chief Plant Quarantine Inspector, Department of Agriculture and Commerce of Porto Rico who has reviewed the portion of this paper relative to the Insular quarantine activities.

Rio Piedras had both spent some time in Hawaii and were well acquainted with conditions in that island and the measures practiced to prevent the introduction of pests. It seemed to them that similar measures should be provided in Porto Rico for the protection of its agriculture as had been provided in Hawaii under laws enacted in 1890 and 1903.

LEGISLATION AND ADMINISTRATION. Plant quarantine service in Porto Rico was provided for originally by Act 60, passed by a Special Session of the Legislative Assembly of the Island and approved on September 3, 1910,—"To prevent the introduction into Porto Rico of plant and insect diseases, and pests, and for other purposes." By this act the Commissioner of Interior was authorized to employ inspectors to inspect all plants, fruits, and seeds imported into the Island. Fumigation, destruction, or deportation of infested material was also authorized. Lack of funds seriously handicapped the start of the inspection service and it was not until February 9, 1911, that arrangements were made with the entomologists of the experiment stations at Rio Piedras and Mayaguez to carry on the work at the ports of San Juan and Mayaguez.

The law to prevent the introduction of insect pests and plant diseases into Porto Rico was revised and a more effective method of administration was provided by the passage of Act 45 by the Legislative Assembly on March 9, 1911. This Act created a Board of Commissioners of Agriculture which took over, among other agricultural activities, the plant quarantine work previously administered by the Commissioner of Interior. The Board of Commissioners consisted of seven members representing the Governor of Porto Rico, the Assembly, and various agricultural interests, such as sugar, fruit, coffee, tobacco, etc. An appropriation of twenty thousand dollars was made available to defray the expenses of the Board. From this sum a sufficient amount was allotted to finance plant-quarantine activities.

The first meeting of the Board of Commissioners of Agriculture was held on June 16, 1911. J. T. Crawley acted as temporary secretary. He remarked that "The most important and immediate responsibility that rests on this Board is the enforcement of regulations to exclude pests. The work is covered under the general head of inspection and quarantine at the ports of entry in the Island as provided by the law creating this body." Apparently, this was the opinion of others on the Board for the first line of work voted to be taken up by them was "To establish a plant quarantine." The duties referred to by Mr. Crawley relating to plant quarantine prescribed in the law were,—"To study insects, pests, smut, and such plant and insect diseases which are harm-

ful or may so become, to the agricultural interests of the Island of Porto Rico, and further, to devise the ways and means to exterminate said pests and diseases already here in existence and to prevent the introduction of others from abroad." Also—"To make rules and regulations, and to amend them from time to time; to enforce quarantines against plants and insects as may hereafter be determined."

W. V. Tower, formerly entomologist of the Federal Experiment Station at Mayaguez, was appointed Secretary of the Board and as Entomologist charged with enforcement of plant quarantines. Following the appointment of Mr. Tower as entomologist, steps were immediately taken to put the provisions of the Act into operation. Deputy inspectors were appointed at Ponce and Mayaguez and fumigation houses were constructed at San Juan, Ponce, and Mayaguez. Importations of plant material were restricted to these three ports. Cooperation was obtained from the Customs Service and Post Office Department to aid in the examination and necessary treatment of contraband articles.

EARLY PROBLEMS. During the first years, particular attention was paid to preventing the entry of tropical fruits as possible carriers of fruit flies and other pests not occurring in Porto Rico. Among many interceptions was one, in nispero from "Curazao", presumably Curacao which was identified by the U. S. Bureau of Entomology as *Anastrepha serpentina* Wied. The entomologist listed, in his first annual report, the following insects and plant diseases as particularly to be guarded against:

"1. Cryptorhyncus mangiferae, mango weevil.
2. Ceratitis capitata, Mediterranean fruit fly.
3. Trypeta ludens, Mexican orange worm.
4. Aleyrodes citri, Florida white fly.
5. Perkinsiella saccharicida, sugar cane leaf hopper.
6. Pachnaeus litus and P. azurescens—blue-green orange beetle.
7. Anthonomus grandis, cotton boll weevil.
8. Atta insularis Guerin, bibijagua.
9. Foul brood disease of bees.
10. Cocoanut bud rot, Phytophthora faberi."

One important exception to the rule prohibiting entry of tropical fruits was the platano or plantain, which is an important article of diet in Porto Rico. As there was no evidence that the green fruit was ever infested with fruit flies or other pests, they were allowed to come in. Many nisperos, mangoes, oranges, and bananas, however, were condemned. Among the interceptions listed in the annual reports of the Entomologist are various scale insects, fruit flies, weevils, moths, white fly, plant lice, mealy bugs, psocids, ants, mites, and mildews. In April,

1913, the entomologist of the Board and the plant pathologist of the Sugar Producers' Experiment Station made a survey of the sugar cane fields in Santo Domingo. As a result of this survey the fumigation of all sugar cane imported from Santo Domingo was required, on account of the presence of the cane butterfly, *Calisto archebates* Men. in Santo Domingo. This was done by burning sulphur in the ships' holds while en route from Santo Domingo to Ensenada and became an important part of the quarantine work at the western end of the Island.

The Federal Plant Quarantine Act became effective August 20, 1912. Almost immediately thereafter the Federal Horticultural Board was petitioned by the Board of Commissioners of Agriculture to include Porto Rico in a quarantine against products capable of carrying the Mediterranean fruit fly from Mediterranean countries, the Canary Islands, and the Azores. Resolutions were also drawn up and presented early in 1913 relative to a sugar cane quarantine. At this time the entomologist of the Board was appointed as a collaborator of the Federal Horticultural Board with authority to enforce Federal quarantines in Porto Rico.

PERSONNEL. For several years following 1914, when Mr. Tower became Director of the Experiment Station, there were numerous changes of personnel in the plant quarantine service and a number of men prominent in Porto Rican entomology and plant pathology were connected with the work. R. J. Fiske, assistant entomologist of the Board, had been placed in charge of plant quarantine work in November, 1913, with headquarters in San Juan. His tenure of office was short, for with the transfer in 1914 of the Sugar Producers' Experiment Station to the Board of Commissioners of Agriculture, the headquarters were moved to Rio Piedras and the entomologist and plant pathologist carried on most of the quarantine work. D. L. Van Dine and T. H. Jones, entomologists at the Rio Piedras experiment station were succeeded by G. N. Wolcott in September, 1914. He carried on the inspection work in San Juan and R. H. Van Zwaluwenburg made the inspections at Mayaguez, since he was the entomologist at the Federal Experiment Station located there. J. A. Stevenson, plant pathologist at Rio Piedras, shared the responsibility of plant quarantine work at that station with Dr. Wolcott. E. G. Smyth took over plant quarantine work in 1916, and remained in charge until September, 1919, except for a few months in 1917, when R. T. Cotton was in charge, and another period in 1918, when the former was in an army cantonment.

The passage of the Jones Bill, which became the Organic Act of Porto Rico, by the 64th Congress of the United States, and its approval

on March 2, 1917, changed the status of plant quarantine work in Porto Rico. The Board of Commissioners of Agriculture was superseded by a Commissioner of Agriculture and Labor appointed by the Governor of Porto Rico, who took over the direction of all agricultural activities on the Island including the Experiment Station at Rio Piedras and plant quarantine work. The Federal Horticultural Board placed in his hands the authority to enforce Federal plant quarantines in Porto Rico and the inspectors engaged in port work were made collaborators. The Insular Plant Quarantine service was made a separate activity by the Commissioner and he appointed Luis A. Catoni as Chief Plant Quarantine Inspector for the Island. Mr. Catoni had been assistant to E. G. Smyth, Entomologist at the Rio Piedras station, and has continued to serve as Chief Inspector through several administrations.

Technical Board of Plant Quarantine

The Technical Board of Plant Quarantine was created September 6, 1919. It consisted of five members—the Director of the Insular Experiment Station, Chairman, the Chief Quarantine Inspector, Secretary, the Chiefs of the Divisions of Entomology and Plant Pathology and the Expert in Sugar Cane Diseases at the Experiment Station. This Board was to study and consider any plant quarantine problem that might arise. It was reorganized in 1923 to include the Agricultural Advisor to the Commissioner, so that it now consists of six members. The first work of the Board was to study the existing laws and regulations in order to effect a close cooperation between the Federal and Insular authorities and to strengthen all local regulations. Some of the quarantines passed upon by this Board include those dealing with the cotton boll weevil, *Anthonomus grandis* Boh., the coffee berry borers, *Stephanoderes hampei* Ferr. and *S. coffeae* Haged., and the Mediterranean fruit fly, *Ceratitis capitata* Wied. It issued recommendations for the treatment of cotton seed following the discovery of the pink bollworm on the Island in July, 1921. The Board approved the agreement reached at the conference of plant quarantine officers held in Washington, April 28–30, 1924, which defined the extent of the authority vested in the various States and territories and the Federal Government.

The Inspector in Charge for the Plant Quarantine and Control Administration has been frequently invited by the Commissioner of Agriculture to attend meetings of the Technical Board, which is an instance of the cordial relations existing between the Federal and Insular departments.

INSULAR PLANT QUARANTINES. One of the first and important quarantine orders issued by the Board of Commissioners of Agriculture was in order to protect Porto Rico from the possible introduction of citrus canker. After investigation by W. V. Tower in Florida in the spring of 1915 the Board took action, effective May 12, 1915, forbidding the importation of seeds, buds, scions, and fruits of the genus citrus and of all kinds of nursery stock from Florida, Alabama, Mississippi, Louisiana, Texas, California, Arizona, and Georgia. This quarantine was amended December 30, 1919, to exclude California and Arizona, from its provisions on account of citrus canker, but citrus is still excluded from these States on account of certain scale insects occurring in them which are not present in Porto Rico.

The importation of all pineapple propagating stock, except seed, was prohibited from any foreign country or the United States, Hawaii and the Philippines by an order of February 21, 1918; Cuba was later excluded from the provisions of this quarantine.

A quarantine notice dealing with the cotton boll weevil, *Anthonomus grandis* Boh. prohibiting the importation of cotton, cotton seed, and cotton hulls from the infested States and Hawaii, was issued May 1, 1919. A shipment of cotton seed from Edisto Island, South Carolina, entered in violation of this quarantine, was found infested January 28, 1920, and was destroyed.

The coffee berry borers, *Stephanoderes hampei* Ferr. and *S. coffeae* Haged., were the subject of a quarantine notice issued July 26, 1922, which prohibits the importation of green coffee from all foreign countries. The Mediterranean fruit fly quarantine issued April 20, 1929, prohibited all classes of fruits and vegetables from Florida, Alabama, Mississippi, Louisiana, Texas, California, Arizona, and Georgia. Upon the revocation of the Federal quarantine this was annulled December 10, 1930.

FEDERAL ACTIVITIES. The Federal Fruit and Vegetable Quarantine No. 56 which became effective November 1, 1923, and which restricted the entry of fruits and vegetables from foreign countries on account of certain injurious insects, including fruit and melon flies, quite naturally did not apply to fruits and vegetables produced in Porto Rico. It was felt, however, that fruit flies of the genus Anastrepha were fairly uniformly distributed throughout the islands of the West Indies, and it was known that two injurious insects, the West Indian fruit fly, *Anastrepha fraterculus* Wied., and the bean pod borer, *Maruca testulalis* Geyer, which were not known to exist on the mainland, were established in Porto Rico. After due notice a hearing was held in Washington on March 18, 1925, by the Federal Horticultural Board to consider the advisability of

restricting the shipment of fruits and vegetables from Porto Rico to the mainland.

This hearing was well attended by members of the U. S. Department of Agriculture, representatives of the Porto Rican Department of Agriculture and Labor, and Federal and Insular Experiment Stations and many fruit growers and others interested in the proposed action. A complete list of insects recorded as occurring in Porto Rico was discussed, and reports were submitted by entomologists of Porto Rico to the effect that there was no evidence of the infestation of citrus fruits in that Island with the West Indian fruit fly.

The Fruit and Vegetable Quarantine of Porto Rico, Quarantine No. 58, was promulgated May 27, 1925, to be effective July 1, 1925. It provided in Regulation 3 that grapefruit, oranges and other citrus fruit, pineapples, bananas, plantains, dasheens, and onions might be shipped from Porto Rico to any other part of the United States when free from leaves, twigs or other portions of plants, and after having been inspected and certified by an inspector of the Federal Horticultural Board, as free from injurious insects. Provision, however, was made in the first proviso of the regulation as follows: That other fruits and vegetables may be certified for movement to the United States when it can be shown to the satisfaction of the Department of Agriculture that such fruits and vegetables, in the form and manner in which they are to be shipped, are not and can not be a means of conveying injurious insects, including the West Indian fruit fly or the bean pod borer.

Under the proviso the following fruits and vegetables have been added since the effective date of the quarantine:

Avocados	Eggplants	Limes	Quenapes
Bananas	Endives	Llerenes	Radishes
Cabbage	Fava beans (note)	Mandarins	Satsuma oranges
Calabashes	Gandules (note)	Muskmelons	Squashes
Cantaloupes	Ginger root	Onions	Strawberries
Carrots	Grapefruit	Oranges	String beans (note)
Cassaba melons	Honeydew melons	Peas	Tamarind pods
Chayotes	King oranges	Peppers	Tangerines
Citrons	Kumquats	Pineapples	Tanniers
Cucumbers	Lemons	Plantains	Tomatoes
Dasheens	Lima beans (note)	Pumpkins	Watermelons

NOTE:—Administratively the shipment of green beans in pods is permitted only during the months of November to March inclusive. Shelled grandules are permitted throughout the year at the port of New York if free from *Maruca testulalis*. This is in accord with the restrictions governing the entry of lima and string beans from Cuba under Foreign Fruit and Vegetable Quarantine No. 56.

Before any of these products were added to the permitted list a field survey was made in Porto Rico and it was determined that they would not be the means of carrying any injurious insects or plant diseases to the mainland.

METHODS OF INSPECTION. The application of the Fruit and Vegetable Quarantine of Porto Rico, Quarantine No 58 was inaugurated by placing C. E. Cooley in charge of inspection with Geraldus Gay as his assistant, with headquarters in San Juan. They arrived in San Juan June 1, 1925, so there were several weeks before the quarantine became effective in which to become acquainted with conditions on the Island. They were authorized to inspect and certify fruits, and vegetables in the fields, packing houses, wharves, etc., in the Island of Porto Rico, for shipment to the mainland, and, as time would permit to cooperate with the Insular authorities in the inspection of plants and plant products, passengers' baggage, ships' stores, crews' quarters, etc., arriving at Porto Rican ports in ships from foreign countries. The inspection work was so well organized under Mr. Cooley's direction that the system devised by him is still is use.[2] The inspection force was increased by the assignment of two more inspectors to duty in Porto Rico. One of them was stationed in Mayaguez at the west end of the Island to take care of the "wild" oranges shipped from that district.

In 1927 all Federal Plant Quarantine activities were transferred to the Federal Inspector in Charge for Porto Rico with the approval of the Commissioner of Agriculture and Labor, Carlos E. Chardon, who had been administering Foreign Plant Quarantines for the Federal Horticultural Board in Porto Rico. This action on the part of the Commissioner was evidence of the spirit of cooperation which has existed between the two services. Luis A. Catoni and several of his deputy inspectors have continued as collaborators assisting in the enforcement of Federal plant quarantines and can be depended upon at all times to enforce such quarantines with the same interest which is evident in the enforcement of Insular quarantine measures.

In the Spring of 1931 two additional Federal inspectors were assigned to duty in Porto Rico primarily to aid in field inspections.

The principal region for cultivated fruit in Porto Rico is a district extending about 40 miles west and 15 miles south of San Juan. Most of the grapefruit and pineapples are grown in this section. The native oranges are grown chiefly in the more mountainous districts near Mayaguez and Aguadilla at the west end of the Island and around Ponce on

[2]March 1, 1928, C. E. Cooley was succeeded by Clyde P. Trotter who in turn was succeeded by Richard Faxon June 1, 1930.

the south coast. Vegetables are grown generally throughout the Island with important centers at Rio Piedras, Loiza and the irrigated land at Isabela. There are some 120 fruit growers who are regular applicants for inspection and about 55 vegetable growers who apply for inspection during the vegetable shipping season.

Applications for inspection are required from all shippers intending to ship fruit and vegetables as far in advance of the probable date of shipment as possible. These applications are used in making up the itineraries of the inspection trips to the packing houses, groves and fields throughout the fruit and vegetable growing districts. The entire fruit and vegetable growing sections are covered as often as possible throughout the year; the principal fruit growing section, at least once a week. Inspection on the docks has proved impractical except for small shipments. Adequate examination of large shipments can not be made during the rush of loading, hence the fruits and vegetables are inspected in the groves, fields and packing houses where a large amount of these products may be examined under favorable conditions for detecting pests. Observations beside a belt conveyor in a packing house gives the inspector an excellent opportunity to note any suspicious looking specimens which can be removed easily for careful examination. Inspections made in the field give the inspector the chance to see the products under natural conditions where all parts of the plant are available for inspection. As will be noted later the field surveys have been the means of detecting certain pests not before recorded as occurring in Porto Rico.

Parcel Post Inspection. In an effort to prevent the shipment to the mainland of parcel post packages containing fruits known to be fruit fly hosts, arrangements have been made with the Post Office Department to examine all parcel post packages for dispatch to the mainland. As all mail and parcel post packages leaving the Island pass through the San Juan post office, an Inspector is assigned to duty in the parcel post room, and there, with the cooperation of the postal employees is able to examine all outgoing packages destined for the mainland. This examination has resulted in removing quantities of fruit, some of which was found to be infested with fruit fly maggots. The inspection in Porto Rico of parcel post packages has the advantage of intercepting fruit fly hosts at the source rather than at post offices on the mainland. A similar arrangment is also in effect with the Post Office Department with respect to the examination of foreign parcels arriving in Porto Rico.

Ship Inspection. Realizing that most tropical and sub-tropical insect pests and plant diseases would thrive in the climate and atmosphere of Porto Rico, and that the existence of the fruit and vegetable

industry of the Island is dependent upon its being kept free from the invasion of foreign insect pests and plant diseases, it has been the aim of those charged with the enforcement of the Federal Foreign Plant Quarantines, to make the inspection of ships arriving at Porto Rican ports from foreign countries as thorough and efficient as possible. Inspectors are kept on duty during all daylight hours, when a ship, schooner, or sloop from a foreign port drops anchor in the harbor, it is immediately boarded by a Plant Quarantine representative along with the Public Health Doctor, and Customs boarding officer. The ship's manifest is examined for contraband cargo, or for material to be entered under permit. A careful examination is made of the crew's quarters and ship's stores. Fruits and vegetables which may be the hosts of fruit flies or other pests are either destroyed or placed under seal aboard the vessel on which they are found. Passenger's baggage is inspected in conjunction with the customs inspection.

In addition to vessels a representative of the Plant Quarantine and Control Administration meets all incoming airplanes and flying boats of the Pan American Airways, which maintains service between Florida, Cuba, Haiti, and the Dominican Republican, other islands of the West Indies, and South America.

PESTS COLLECTED. During the early years of plant quarantine work in Porto Rico, the interceptions of pests by the Insular inspectors were principally made in host plants entering the Island. Since the establishment of the Federal plant quarantine office in Porto Rico the aim has likewise been to prevent the exportation of pests from the Island to the mainland. Quarantine No. 58 refers specifically to the West Indian fruit fly, *Anastrepha fraterculus* Wied., and the bean pod borer, *Maruca testulalis* Geyer. However, careful watch is kept for any insect or plant disease which might develop into a pest in the continental United States. Up to September 1, 1931, over 1,500 specimens had been found by inspectors in Porto Rico and forwarded to Washington for determination. They were found in cargo, ships' stores, and passengers' baggage entering Porto Rico, in fruits and vegetables consigned to the mainland, and by far the greatest number were taken in the field. These collections include many duplications but some 332 species of insects have been determined and 70 plant diseases. In addition some 100 insect specimens could be assigned to genera only. In this way information is accumulating of increasing value as to the presence of various pests in the Porto Rican products examined.

The West Indian fruit fly, *Anastrepha fraterculus* Wied., has been reported as infesting mango, *Mangifera indica* L., guava, *Psidium*

guajava L., jobo, *Spondias mombin* L. and pomarosa, *Eugenia jambos* L., in Porto Rico. In April, 1931, a few fruit fly larvae were found in grapefruit in the vicinity of Mayaguez. These larvae resembled those which had been previously determined as *Anastrepha fraterculus*. By the first of May the Federal inspection force was increased by the arrival of C. E. Cooley and two inspectors who had had experience in the Mediterranean fruit fly campaign in Florida, bringing the number of Federal inspectors to seven. In addition the Insular Plant Quarantine office furnished three or four men whenever possible. A careful survey was commenced immediately of all citrus on the Island. This scouting, which extended for three months, resulted in finding 110 specimens, most of them in sour oranges and grapefruit. One larva was found in the native sweet orange or "china" and twenty larvae were found in cultivated orange. Exceptional conditions prevailed during the season with all citrus fruit hanging for two or three months beyond the normal picking time so that it was all very ripe. The cultivated oranges found infested were all of the "crease-skin" type with the skin very thin and showing very little oil in the oil cells It was exceedingly difficult to rear adults from the limited supply of material which was collected, especially from the later collections in May. Citrus is apparently not a congenial host for the strain of Anastrepha found attacking it in Porto Rico since both pupae and adults were found in the flesh and rag of the fruits examined.

Specimens from all of the collections were forwarded to Washington for determination where a question has arisen as to what species of *Anastrepha* occurs in Porto Rico. There are apparently two strains which are differentiated to some extent by their host plants,—one strain infesting jobo and some varieties of mango and the other infesting guava, pomarosa and almendro. Almendro, also known in Porto Rico as bitter or tropical almond, *Terminalia catappa* L., has only recently been added to the known hosts of *Anastrepha* sp.

The shipment of fruit to the mainland from infested groves was immediately prohibited and no citrus fruit from Porto Rico was allowed to be shipped to Southern or California ports. All fruit from infested groves was disposed of locally or shipped to Europe by direct steamer.

The bean pod borer, *Maruca testulalis* Geyer, has been found generally infesting lima and string beans, especially during the winter, and in addition has been found in gandules, crotalaria and canavalia or Jack Bean. Two other lepidopterous larvae, *Etiella zinckenella* Tr. and *Fundella cistipennis* Dyar, are also frequently found in bean pods in Porto Rico. The bean lace bug, *Corythuca gossypii* Fabr., generally

infests lima beans, especially during the summer months, and prevents the setting of pods. Lima-bean scab, *Elsinoe canavaliae*, has been frequently found on pods, leaves and stems.

General scale insects commonly found on citrus fruits occur on grapefruit and oranges in Porto Rico. The following are the most important on the Island:

Purple scale, *Lepidosaphes beckii* (Newm.)
Rufous scale, *Pseudaonidia articulatus* (Morg.)
Orange chionaspis, *Chionaspis citri* Comst.
Chaff scale, *Parlatoria pergandii* Comst.
Florida red scale, *Chrysomphalus aonidum* (L.)

The sugar cane root weevil, *Diaprepes abbreviatus* L., is often found feeding on the foliage of citrus trees. A leaf-footed plant bug, *Leptoglossus gonagra* Fabr., has been observed damaging oranges and grapefruit by puncturing the fruit and extracting the juice, causing a corky area beneath the peel. The spotted root fly, *Euxesta notata* Wied., has been taken many times from oranges and less frequently from grapefruit. It has not been proved how this insect gains entrance to the fruit but it seems probable that the infestation is secondary. Melanose, *Phomopsis citri* Faw., and citrus scab, *Sphaceloma fawcettii* A. Jenkins, are generally distributed on grape fruit and *Colletotrichum gloeosporioides* Penz., is also common on the same host.

Pineapples have been found relatively free from pests except for the pineapple mealybug, *Pseudococcus brevipes* (Ckll.), which is generally distributed throughout the pineapple plantings.

Papayas have been found infested with the papaya fruit fly, *Toxotrypana curvicauda* Gerst., at Lares, Mayaguez, and Ponce, and the trees and fruit are usually coated with West Indian peach scale, *Aulacaspis pentagona* (Targ.).

Tomatoes, peppers, eggplants, and cucumbers are the most commonly grown vegetables for export to the mainland. Several lepidopterous larvae have been intercepted which were feeding in them— *Diaphania* sp., *Heliothis obsoleta* Fab., *Prodenia* sp., and *Polia* sp.

Heliothis virescens Fab. has been frequently taken in pigeon peas.

The rattle-box moth, *Utetheisa ornatrix* L., is found generally infesting Crotalaria.

Okra pods have been found infested with the pink bollworm, *Pectinophora gossypiella* Saunders, and this species also has been present in cotton, tree cotton, and the bolls of the Maga tree, *Montezuma speciosissima* D.C.

Two important insect pests of the banana have been found in the field, *Cosmopolites sordidus* Germar, and *Metamasius hemipterus L.*

The records of interceptions made in fruits, vegetables, and other plant material from foreign countries in Porto Rico have already been published in annual reports of the Insular Department of Agriculture and Labor and in the Annual Letter of Information of the Plant Quarantine and Control Administration, therefore no mention of them is necessary in this paper.

OTHER QUARANTINES ADMINISTERED. Practically all Federal Foreign Plant Quarantines afford protection to Porto Rican agriculture and are administered through the San Juan office of the Plant Quarantine and Control Administration. By far the largest number of permits issued at the San Juan office are for shelled corn from the Dominican Republic under European Corn Borer Quarantine (Foreign) No. 41 and for plantains from the Dominican Republic and garlic from Spain under the provisions of Fruit and Vegetable Quarantine No. 56. Several permits have also been issued under Regulation 3 of the Nursery Stock Quarantine No. 37. Special permit material entered in accordance with Regulation 14 of this quarantine is permitted through the Washington office and the annual inspections are made by the inspectors stationed in Porto Rico. Most of the inspections required in enforcing Quarantines Nos. 41 and 56 are made by Insular collaborators under Federal direction.

In addition to Quarantine No. 58, shipments of Porto Rican products to the mainland are regulated by the following Federal Quarantines which are enforced at the port of first arrival on the mainland:

No. 16. Sugar cane (insects and plant diseases).
No. 30. Sweet potato and yam (weevil and scarabee).
No. 32. Banana plant (weevils).
No. 47. Cotton (pink bollworm and blister mite).
No. 60. Sand, soil or earth (white grubs and termites).

RECENT OBSERVATIONS ON STRAWBERRY DWARF

By NEIL E. STEVENS and PAUL V. MOOK

ABSTRACT

When, some months ago, Doctor Fracker invited us to discuss strawberry dwarf at this meeting, we asked him what phases of the subject would most interest those present. He replied with characteristic directness, "What dwarf looks like, where it is now found, its economic importance, and whether it is susceptible to treatment by nursery inspection methods."

We will give what we have to say under these four heads and in just the order in which Doctor Fracker gave them to us over the telephone.

SYMPTOMS OF THE DISEASE. The figure in U. S. Department of Agriculture Circular 174 (a copy of which is here for each of you) gives a good idea of the appearance of a severely diseased strawberry plant of the Klondike variety during the summer months in North Carolina. The first good printed description of the disease was that given by Plakidas[1] based on the Louisiana material, and it has been well described by Brooks.[2] Both published excellent figures.

The names "dwarf" and "crimp" which are often applied to this disease by growers in the Southern States indicate its most conspicuous symptoms. The edges of the leaves are crinkled and the size of the leaves is reduced. In extreme cases the entire plant is dwarfed and the internodes of the runners are shortened. In Florida, even the flowers may become distorted and the fruit when it matures be misshapen. These symptoms are most conspicuous in midsummer. Although with continued study some of the men who see the disease most often in the field have become able to distinguish it in early spring, our experience leads us to believe that the average man can distinguish it with reasonable certainty only during the summer months.

Dr. N. A. Cobb and Dr. G. Steiner, who first identified in this country the nematode now known to cause strawberry dwarf, consider it identical with *Aphelenchus fragariae* of Europe. In Europe the disease of strawberries caused by this nematode is known as the "cauliflower" disease, because the diseased plants usually show a close bunching of numerous buds on an enlarged stem. The senior author has seen, in England, fresh as well as preserved specimens of strawberry plants affected with this disease and the resemblance to a small cauliflower is certainly striking. We have never yet found this particular malformation in this country nor has anything quite like American "dwarf" been found in Great Britain. Whether this is due to difference in variety, in climate, or some other factor has not been discovered.

WHERE THE DISEASE IS FOUND. In Europe the "cauliflower" disease is recorded from England, Germany, France, Belgium, Holland, Denmark, Norway, and Sweden.

In the United States "dwarf" has been long established in the strawberry producing areas of the Southeastern States from North Carolina to Louisiana. Bessey found what he believed to be this disease in South Carolina in 1905 on plants brought from North Carolina and it has apparently been fairly common throughout the Southern States

[1]Plakidas, A. G. 1928. Strawberry Dwarf. Phytopathology 18: 439–444, illus.
[2]Brooks, A. N., Watson, J. R., and Mowry H. 1929. Strawberries in Florida: Culture, Diseases, and Insects. Fla. Agr. Expt. Sta. Bul. 204, p. (481–523, illus.

ever since. During the seasons 1915 to 1918, Mr. R. B. Wilcox was in the field in southern strawberry sections in connection with work he was then doing on fruit rots of strawberries. He made a number of careful notes on his observations of the dwarf disease from which it is evident that the disease was, at that time, widely scattered and generally recognized by growers in Florida and Louisiana. By 1919, we were accustomed to thinking of it as common in the Southern States. During this same period and throughout the succeeding years up to 1930, many visits were made to strawberry fields in various Northeastern States for the study of strawberry diseases. In none of these States was anything closely resembling dwarf observed.

Due to an exceptional combination of circumstances we are able to present an unusually complete record of the present distribution of strawberry dwarf. In the summer of 1930, the junior author started a field survey to determine, as far as possible, the northern limits of the distribution of this disease. After he had already started on this work our attention was called to the fact that a number of shipments had been made of the new Blakemore variety from a region in North Carolina where the disease existed and some of which were presumably infected. This gave an excellent opportunity to study distribution and spread of the disease and during the summers of 1930 and 1931, he devoted a large part of his time to studying the occurrence of this disease in the Northern States. State pathologists and nursery inspectors were notified of the possible introduction of a new disease and many of them gave assistance. Throughout both seasons Doctor Steiner was active in examining suspicious plants and identifying the nematodes. In this he was assisted by Doctor Chitwood during 1930 and by Mr. Christie during 1931. Both the latter investigators did field work as well.

The result of this survey is given on the accompanying map (Figure 28). You will see that the dwarf disease has been found on old established plantings only in the South, although a few Howard 17 plants were found in Massachusetts, which harbored the nematode without showing symptoms of the disease. North of the Arkansas, Tennessee and North Carolina boundary (approximately 36° 30′ N.L.) the disease was found on recently introduced varieties or experimental plantings in the Norfolk region of Virginia, the "Eastern Shore" of Maryland, in Delaware, in southern Illinois and at Lebanon, Pennsylvania. In those plantings of recently introduced varieties which were found infected, only a few fields in southern Maryland showed more than a small percentage of dwarf, the others showed 5 per cent or less of the plants diseased. In only two fields, both in southern Maryland had the dwarf disease

apparently spread even slightly to standard commercial varieties of strawberries. At other places in the Northern States, where Blakemores from an infected region have been planted, it was not possible to

Distribution of strawberry dwarf caused by Aphelenchus fragariae, 1931.
(Information largely from surveys made by Paul V. Nook.)
See text
See text
X Blakemore and other varieties inspected. Dwarf not found.
△ Found in 1930 or 1931 on recently introduced varieties or in experimental plantings.
◎ Found in 1930 or 1931 on commercial plantings of standard varieties.
□ Disease long known to be abundant.

FIG. 28—Distribution of Strawberry Dwarf.

find either the causal organism or symptoms of the disease except at Falmouth, Massachusetts, where the situation presents so many unusual features that it is discussed in some detail.

In the spring of 1930 one thousand Blakemore strawberry plants from North Carolina were set in the town of Falmouth, Massachusetts.

These were distributed among a number of growers, two of whom had 250 apiece, the others only small lots. In the spring of 1931, after receiving the notice regarding these plantings, Dr. O. C. Boyd, Extension Pathologist of Massachusetts, visited Falmouth and found in one patch several suspicious looking plants among the Blakemores, which were subsequently proven to be infected with *Aphelenchus fragariae*. These were all apparently parent plants which had been brought from North Carolina. In June, Doctor Boyd, Mr. J. R. Christie, and Mr. Tomlinson, the County Agent, made a careful re-survey of this area and found a few nematodes of this species on Blakemores in the same patch and a few on Howard 17 in another patch. In September, 1931, these same men made a careful re-survey of this area and a few *A. fragariae* were found in the Howard 17 plants from the field just mentioned, but none could be found on any of the Blakemores. There was no evidence of symptoms of dwarf either on old plants of Blakemore or new plants of Blakemore, or any of the Howard 17. Apparently, in spite of the fact that the nematode was introduced at least as early as the spring of 1930, up to the fall of 1931, that is after two growing seasons, the disease had accomplished nothing in that region. Of course we are not sure why the disease is not more common in the Northern States, but our recent experience in eastern Massachusetts may be significant.

Of course, it cannot be proved that any of the lots of Blakemore strawberries planted in the States of Minnesota, Michigan, Ohio, New York, Indiana, Kentucky, or in northern Illinois or northern Pennsylvania were diseased. It is, however, probable that they carried a small proportion of infected plants, as did those lots from the same nursery which were planted a few hundred miles further south. From this summer's survey, which ought, we believe, to be repeated next year, it appears that the disease, if introduced, did not establish itself in any of the localities just listed. Whether the nematodes survived without producing the disease is quite another question.

Whether dwarf will ever become important in the Northern States is, of course, an unanswerable question, but at present it is surely a southern problem and our experience to date makes it appear safe to say that in regard to yield, the disease is of greatest economic importance in the South and decreases in severity as we go northward. On the other hand, nurseries, either in the North or in the South, which expect to supply southern growers with strawberry plants will find it necessary to use every precaution to keep their plantings free from this disease as the wise southern grower simply will not continue to buy plants from dwarf infected nurseries.

ECONOMIC IMPORTANCE. The question of economic importance is one we feel least competent to discuss. With the possible exception of the losses which occur in transit and on the market it is doubtful if we have the information to approximate even vaguely a dollar value for plant diseases. Even in the matter of estimating percentage loss we are still in the kindergarten. The problem of determining losses from plant disease and the methods of estimating such losses are among the recognized functions of the Plant Disease Survey. It is, however, a line of study which has been but slightly developed. It is hard to estimate losses from disease when we so rarely have disease-free checks or a disease acting alone. In the case of strawberry dwarf, for example, we find it frequently associated with root rots which cause losses as yet undetermined. With these qualifications you will not expect us to be very specific. We may, however, quote Brooks and Plakidas who have studied the disease more extensively in the field than anyone else. Brooks discussed losses in Florida due to this disease as follows: "The loss of plants due to crimp is 0 to 75 per cent in individual fields and about 2 per cent for the entire State (Florida)." Plakidas' statement quoted at length on Page 5 of U. S. Department of agriculture Circular 174 puts the decrease in yield from dwarf in an average field between 1 and 2 per cent for Louisiana.

We have no criticism of the loss estimates made by these competent and conscientious observers. The figures they give are, of course, based on the Klondike and Missionary varieties and on present cultural practices. Cultural practices developed through years of contact with the dwarf disease and which include a short rotation, more or less roguing in connection with the regular hoeing of the field, and, in the case of Florida, regular importations of plants from northern nurseries. These are exactly the practices which seem best adapted to hold this disease in check and it is our belief that they were developed in a partly unconscious response to the disease.

These practices were well established in 1915 when Mr. R. B. Wilcox made a survey of strawberry conditions in Florida and Louisiana with special reference to this disease. The chief differences between cultural conditions as reported by Wilcox in 1915 and those described by Dr. W. A. Taylor in 1892 (Report Secretary of Agriculture, page 251) are that at the later date the practice of buying new plants from the north had become well established and the Missionary had replaced the Neunan, which was the only variety grown in any quantity in 1892. At least one experienced grower, Mr. J. M. Brownlee, Starke, Florida,

assured Wilcox in 1915 that the Neunan had this disease (which he called 'White Buds") "much worse" than Missionary.

CAN THE DISEASE BE CONTROLLED BY NURSERY INSPECTION METHODS. The question of the possibility of the control of this disease by nursery inspection methods would seem to be peculiarly one for your decision. We are very glad, however, to give our opinion. We hesitate to say that the disease cannot be controlled by any other methods because someone may, any day, discover one. Crop rotation probably will help. Hot water treatment will serve for a few very valuable plants, but, in its present form, is not likely to be useful for large quantities. It is our honest opinion, based on field observations and acquaintance with the disease, that adequate nursery inspection and careful certification offers the simplest, most direct and most promising line of attack.

Adequate inspection combined with careful certification, on the other hand, gives us a weapon immediately worth using. This inspection should be made not only in the spring but during the summer months. As an illustration of the difference in plants as they are received from the nurseries, let us recite our experience in Chadbourn, North Carolina. We planted in February and March, 1929, six lots of Klondike strawberry plants from widely separated sources. Examination for dwarf in October, 1929, showed the following percentages of the disease: Plot 1–0; Plot 2–0.5; Plot 3–0.3; Plot 4–0.8; Plot 5–5.0; Plot 6–5.0. The advantage of the grower who purchases his plants from nursery No. 1 or No. 2 as compared to those from nurseries Nos. 5 and 6 is obvious.

BROADER ASPECTS OF NURSERY INSPECTION IN RELATION TO STRAWBERRY DISEASES. We would like to go one step further and state our belief that the whole strawberry industry would benefit from a greatly strengthened system of nursery inspection. In eastern Massachusetts and adjacent parts of New England, strawberry growers are faced with a peculiar disease of strawberries known, among other names, as "Gold Leaf" and "June Yellows". Of this, we know neither the cause nor the cure, but in three years' field study in that region we have failed to find diseased plants which could not be traced more or less directly to a certain community. It is well within the grounds of probability that they originally came from a single nursery. Adequate nursery inspection would, we believe, eliminate this disease as a commercial factor within three to five years, but inspections would have to be made in June as the disease is most readily observed at that time.

We do not know whether the laws under which you operate permit your cooperation in such action, but we would like to see a nation-wide drive for the certification of really disease-free strawberry plants, to be

sold at a premium, which they would abundantly deserve. Such a plant as the strawberry offers the nursery inspector a special opportunity and places on him a special obligation. Fruit trees are sold chiefly to big growers and last from twenty to forty years, but many strawberry growers, big and little, buy plants almost every year. Your opportunity for effective disease control is correspondingly increased.

AN OUTLINE OF IRISH AND SWEET POTATO CERTIFICATION PROCEDURE IN TENNESSEE

By G. M. Bentley

Irish Potato Certification. Tennessee Requirements.

1. Application for certification service must be made before March 1, on blanks furnished by the Division of Plant Disease Control, University of Tennessee, Knoxville, Tennessee.

2. Only standard, commercial varieties will be considered for certification. All mixtures, weak plants, and off types must be rogued before the first field inspection. Two percent of such plants at the time of any inspection will disqualify.

3. Only seed potatoes certified by a recognized certification service shall be planted.

4. The potatoes must be planted in a field on which potatoes have not been grown for at least three years. The field must be at least 150 feet distant from any other potato field of the current year.

5 The tubers must be properly treated at the time of planting.

6. The crop must be kept free from weeds.

7. In the field intended for certification, all diseased plants including the tubers must be rogued as soon as they are observed. The potatoes rogued out must be removed from the field and destroyed, preferably burned.

8. If the following percentages of disease are present at any inspection, the field will be disqualified: (a) A total of any or all virus, or degeneration, diseases—5% of plants; (b) A total of any or all fungous diseases—2% of plants or of leaf area.

9. If at any time the stand shall be under 90% the field will be disqualified.

10. The potatoes must be sprayed in order to keep the field free from insects and diseases.

11. The potatoes must be stored where they will neither freeze nor become overheated. The place of storage must be disinfected with

corrosive sublimate, formaldehyde, or some other disinfectant acceptable to the inspector.

12. Samples of all seed which are officially sealed and tagged may be required and planted in a place designated by the inspector to enable him to check on the quality of the grower's seed stock. This may also serve to protect the grower against possible complaints.

TENNESSEE STATE CERTIFIED SEED POTATOES. This grade shall consist of one variety of potatoes certified by the Division of Plant Disease Control, State Department of Agriculture. The tubers must be true to the varietal name, mature, well shaped, and free from freezing or overheating injury, any rot, dirt or other foreign matter, sunburn, second growth, growth cracks, hollow heart, cuts, scab, blight, insect, mechanical, or other injury. The size of the tubers shall be U. S. No. 1.

In order to allow for variations incident to proper grading and handling, not more than five (5) percent, by weight, of any lot may be below the prescribed size, and, in addition, not more than six (6) percent, by weight, may be below the requirements of the specified grade, but not to exceed one-sixth (1/6) of this six (6) percent tolerance shall be allowed for potatoes affected by any storage rot.

Potatoes of this grade shall be in NEW even weight cloth or fiber sacks (such as are customarily used for commercial shipment of potatoes) containing one hundred (100) pounds net weight. Each sack shall be tagged with the official tags issued for "Tennessee State Certified Seed Potatoes" and shall bear no other tag, brand, or label which in any way indicates any grade of potatoes.

METHODS OF SEED TREATMENT. 1. Corrosive Sublimate Method: Materials: (1) Several barrels or other wooden containers, the number depending on the quantity of potatoes to be treated. (Do not use metal containers.) (2) Wooden crates for each container. (Do not use burlap sacks or metal crates.) (3) Corrosive sublimate (Mercuric Chloride).

Procedure: (1) Pour 28 gallons of water in each barrel. Heat 2 gallons of water and dissolve 4 ounces of corrosive sublimate in it. (Corrosive sublimate does not dissolve readily in cold water.) Add this solution to the water in the barrel. Mark the water level so that time may be saved when refilling. (2) Wash the potatoes to free them from dirt. (3) Submerge the crates of potatoes in the solution and leave them from ½ to 1½ hours, depending on the water temperature and the amount of Rhizoctonia. (4) When the potatoes are removed, they may be cut immediately for planting, or stored for a short time in a disinfected place before they are cut. (5) When about 10 bushels have been treated

in each 30 gallons, add ½ ounce of corrosive sublimate to the solution and fill the barrel with water up to the original volume. (6) After 5 treatments, empty the barrel and refill as originally done. This is necessary since the strength of the solution varies with use.

Caution: Corrosive sublimate is a poison if taken internally. Do not allow stock to drink the solution. All potatoes which are treated and not used for seed should be destroyed.

2. Modified Corrosive Sublimate Method: Materials: The same as above with the addition of commercial (40%) hydrochloric (muriatic) acid.

Procedure: (1) The same as above with the addition of 1 quart of acid (1% of the solution) to the original solution. (2) Soak the potatoes 10 minutes. (3) Pile them about one foot deep and cover them with sacks over night.

3. Cold Formaldehyde Treatment: This treatment is not advisable since it is relatively ineffective against Rhizoctonia.

4. Hot Formaldehyde Treatment: This treatment is not recommended since it is impracticable on many farms.

Sweet Potato Certification. Tennessee Requirements.

1. One-tenth of the seed in storage will be examined by the inspector and if there is an infection of 2% black rot, no certificate will be issued.

2. To be eligible for certification, the grower must start out with either certified seed or certified plants and these must be grown on soil which has not been in sweet potatoes for at least five years.

3. The certified seed must be dipped according to the regulations of the Division of Plant Disease Control and That Done in the presence and under the supervision of the inspector. No certificate will be issued unless the grading, dipping and bedding is done under the supervision of the inspector.

4. If new beds are not used, the old ones must be cleaned out and disinfected with copper sulphate 5 pounds to 50 gallons of water, or corrosive sublimate 2 ounces to 8 gallons of water. (Plant growers should call on the inspector to assist or be present when this is done.)

5. No certified grower can bed both certified and non-certified seed. All must be certified. No plant dealer can sell both certified and non-certified plants.

6. All beds which develop black rot to any extent or beyond control will be condemned. These must be dug up and destroyed by the inspector or in his presence or certificate revoked and tags surrendered.

7. Potatoes which show a total of 10 plants infected with stem rot in both field inspections will be condemned.

8. Potato seed or plants showing a mixture of varieties will not be certified even though they are free from diseases, unless the grower will agree to dig the off varieties out. This must be done before the second field inspection.

9. All requests for Certification must be filed in the office of the State Entomologist by March 1.

MARKETING CALIFORNIA'S EARLY POTATO CROP, AN EXAMPLE OF QUARANTINE ENTOMOLOGY

By D. B. MACKIE, *Sacramento, Calif.*

To some of you the term "Quarantine Entomology" may be somewhat of a misnomer. For the purpose of this paper I will define it as "a treatment which is mandatory as a condition of movement for some specific commodity."

I have chosen California's potato crop as an example in this respect, as its movement has heretofore been circumscribed both by interstate and international quarantines. It has also involved questions pertaining to transit privileges on trunk line railroads which have had no small bearing upon its success. It also furnishes an example of the many different factors which bear upon a problem of this kind as compared with ordinary problems of entomology.

As most of you know, California potato fields are at times infested with the potato tuber moth, *Phthorimaea operculella*, according to seasonal conditions. The species does not exist in a number of states which themselves grow large quantities of potatoes, and the people of these states desire early potatoes. Their agricultural officials feel that a great hazard is involved in their importation, as the immature tuber moth lives within the potato tuber which furnishes a most excellent vehicle for its distribution over long distances. This habit, I might add, also makes it impossible to obtain the desired freedom from infestation by means of any known pest control practice that might be adopted.

From the standpoint of a quarantine problem, its history is interesting, particularly as to the means taken by the various states to protect themselves against it. For the past 17 years a number of attempts have been made to develop a method that will allow movement without hazard. The first interstate discussion of the Status of this pest was in May 1919 at the inaugural conference of the Western Plant Quarantine Board. Discussion of the pest occupies seven and one-half

printed pages, which, I may add, points out the inadequacy of the results previously obtained.

Prior to the aforementioned meeting, the movement of potatoes from California was circumscribed by the following regulations:

Canada and Idaho—embargo,

Oregon and Washington— potatoes passed only by their own inspectors, who visited California and certified at point of origin,

Montana, Utah and Colorado—destination inspection.

As Oregon and Washington are the heaviest consumers of California's early potatoes, it is interesting to view their methods. As early as 1916, potato dealers in those states defrayed expenses for a Washington State Inspector, who came to California and certified the shipments which should be allowed to move into either of these two states. In 1916 he inspected 80 carloads of potatoes, 65 of which were passed. In 1917 he passed 90 carloads out of 125 inspected. In 1918 he passed 206 carloads out of 275. It would seem that a rejection of 69 out of 275 cars examined in 1918 pre-supposed a fairly heavy infestation of tuber moth. It may also be asked, if so many shipments were found infested, is there ground for presumption that all infestations had been detected? Whether officials of Oregon and Washington felt there was still some hazard or because California growers and dealers felt that the methods employed favored some shippers at the expense of others, I will not presume to say. However, in November 1920, an interstate conference was called at Portland, Oregon, (by Chas. A. Park, then Commissioner of Oregon) to discuss the California potato question in reference to this pest. As a result of this meeting, California shippers stood out for certification of potatoes on the basis of clean areas rather than upon an inspection-of-shipment basis. While this plan was opposed by entomologists as being impracticable, it was felt by the industry that the plan was workable. It was finally accepted and provided that the Shipping Point Inspection Service of the Department of Agriculture of California should inspect the fields of growers who wished to dispose of their potatoes in Oregon and Washington, and to certify the crop from such fields as were clean. While this was not difficult during the earlier part of the shipping season, the plan resulted in growers and shippers being unable to fill contracts when the tuber moth injury began to show up.

In its endeavor to protect its northern markets and not to break faith with the officials of those states who had accepted certification, the department found itself getting into hot water, particularly with those dealers who were concerned only in trading in potatoes.

During this time, experiments were begun in a small way with vacuum fumigation with different gases to test out their possibilities of destroying tuber moth. As a result, it was found that in the laboratory a dosage of above 20 lbs. of carbon disulphide per 100 cu. ft. of space for a period of 75 minutes was 100 per cent lethal to any stage of tuber moth that might be exposed to such an environment.

In 1924 the limitations of the former plan of the field inspections were brought home to the growers and dealers in a most forceful manner. Mild winter weather and an early spring was eminently favorable to tuber moth, which appeared early in large numbers. Cold weather in Texas caused a scarcity of early potatoes and also induced high prices. The inevitable happened. Everyone with potatoes to ship desired to ship them. However, due to the presence of tuber moth, this market was, figuratively speaking, lost practically over night. A delegation of growers and shippers approached both the Governor and the Director of Agriculture of California to demand relief and permission to allow the continued movement of potatoes; though I might say that they early found that this question was not one for California to answer, as it concerned solely other states.

In the resulting emergency, the department's work became known to the industry. Though assured that the department had nothing but laboratory experiments on which to base its conclusions, a certain group of growers felt that larger tests would furnish a basis for further action, and demanded extensive tests. Several hundred pounds of potatoes in commercial containers were treated by various methods and examined by a committee of the industry, and met their approval from the standpoint of effects of the treatment. They decided that they had to have fumigation apparatus immediately. The writer was asked to design fumigation equipment of commercial size, which included generators such as had never before been designed, the entire operation to be completed and the fumigators in operation in 20 days.

Making a long story short, a duplex type of fumigator was built, and except for the usual incidental troubles and minor modifications, the plan worked. During the remainder of the season, some 56 carloads of potatoes were treated, and though subjected to rigid inspection, no live tuber moth were found.

Trouble, however, of a different nature was not long developing. The possession of proper facilities gave this group of growers the northern market practically to themselves. The California Department of Agriculture was accused of having sold out the industry to a certain group. A second consequence was that due to the high price of potatoes

there developed a tendency to attempt to ship everything. To correct this, rigid regulations governing the shipment of potatoes were set up, not only to protect our market, but also as a token of good faith to those who had agreed to accept certification. Schedules were set up by California and approved by the receiving states.

1. That all potatoes delivered for treatment should be apparently free from tuber moth.
2. That they should be treated at the specific dosages for a stipulated product, for a given period and under certain conditions of temperature.
3. That they should be handled in a manner that would prevent post-fumigation infestation.
4. Their continued identity should be established.

In this manner the inspector certified to a treatment which was supposed to bridge the gap between the inability of human effort to find the last individual tuber moth and the presumption of infestation that existed when tuber moth occurred in the area where the plants were grown.

In this manner California was able to hold these markets. For two years the work went on without any converts to our particular faith. However, in 1926, Idaho removed her embargo and accepted the certification of fumigation as evidence of freedom from infestation. In 1927, the Dominion Government of Canada revised its embargo and allowed their movement. Other western states agreed to accept our fumigated potatoes. As a result, California potatoes can now be shipped into any of the Pacific inter-mountain states any time in the year. The Republic of Mexico at one time placed a quarantine against California potatoes, but still allowed the movement of the treated potatoes.

While I am perhaps ahead of my story, serious obstacles to the potato movement were not removed for a number of years. In view of this fact that the dealer, who was not a grower nor a member of an association which had fumigation facilities, sometimes lost his best market. However, as the demand increased, commercial fumigation facilities were developed in San Francisco, Shafter and Los Angeles, which enabled this type of business.

However, one serious obstacle persisted, which was not corrected by the commercial fumigator. The railroads demanded freight both to and from the fumigation plants, and consequently two bills of lading. In 1926 an unsuccessful attempt was made to secure a treatment-in-transit privilege, which was denied by one railroad, though promised by another. As this privilege had been extended in many other commodities, it was felt that potatoes consigned to distant points which required fumigation

should be allowed to be shipped to an intermediate point for treatment without being subjected to the double hauling charge. In 1928, the treatment-in-transit privilege was accorded fumigated potatoes, a consideration which has perhaps given the greatest boost of anything, as the differences in the freight charges have so reduced the hauling costs that the difference takes care of the fumigation charge.

The treatment has been in operation seven years. As none of the privileges extended California by her sister states have been rescinded, it may be assumed that our treatment has been more or less of a success. That such a condition of affairs is true may also be concluded by the fact that the number of cars which are shipped is annually increasing. The first season showed only 56. 1931 will show over 500, opposed to 276 treated in 1930. Thus, by means of a treatment it has been possible not only to conserve those markets which we formerly had, but we are now shipping not only to the Pacific and intermountain areas, but potatoes have been marketed as far east as Kansas City, and also as far as Winnipeg in the Dominion of Canada. The only restriction whatever placed upon their movement is that the treatment prescribed in the certificate shall be attested to by a reliable inspector.

SUGARCANE INSECT PESTS AND DISEASES WITH SPECIAL REFERENCE TO UNITED STATES PLANT QUARANTINES[1]

By T. E. Holloway, *U. S. Bureau of Entomology, New Orleans, La.*, and R. D. Rands, *U. S. Bureau of Plant Industry, Washington, D. C.*

Abstract

Insects and diseases likely to be introduced in shipments of sugarcane are mentioned, together with measures designed to prevent their introduction.

When the Secretary of the Section on Plant Quarantine and Inspection kindly proposed that the authors write a paper on this subject, he suggested that sugarcane pests and diseases be discussed with special reference to those made the subject of plant quarantines. A very superficial examination, however, not only of United States but of foreign literature, showed that in plant quarantine regulations few specific diseases and fewer insects are mentioned. This may or may not be unusual, but it appears that the officials of the various countries were

[1]Paper read before the Section on Plant Quarantine and Inspection at the 44th Annual Meeting of the American Association of Economic Entomologists at New Orleans, La., December, 1931.

wise in making the quarantines broad enough to cover all undesirable insects and diseases.

In regard to state quarantines, the states of Arizona, Florida, Georgia, Louisiana, and Mississippi have promulgated quarantine laws specifically restricting the importation of sugarcane, and California has a law restricting the importation of certain plants from Hawaii, which would include sugarcane.

The regulations of Florida, Georgia, and Mississippi were adopted specifically on account of the mosaic disease at a time when the distribution of this disease was not completely known; at any rate it has since been found in all three states. The regulations of Arizona (adopted Nov. 15, 1923) and of Louisiana (effective Jan. 1, 1928) are general regulatory measures likewise designed to prevent the introduction of pests and diseases from other states, while that of California (effective June 24, 1911) apparently from its wording would also exclude sugarcane from Hawaii due to the danger of introducing the Mediterranean fruit fly.

As to the United States, two national quarantines have been promulgated on sugarcane; Quarantine No. 15 (Foreign) announced June 6, 1914, prohibits the movement from all foreign countries into the United States of living canes of sugarcane or cuttings or parts thereof; and No. 16 (Domestic) which is essentially the same as No. 15, relates to the movement of sugarcane from the territories of Hawaii and Porto Rico. While these quarantines make no specific provision for the shipment to the United States of sugarcane for scientific or other purposes, the Plant Quarantine and Control Administration has for a number of years administratively permitted such introductions provided they were addressed to the Inspection House of the Plant Quarantine and Control Administration, and were grown in the quarantine greenhouse at Arlington Farm, Va., and not removed therefrom unless certified by inspectors of the Administration to be apparently free from injurious insects and plant diseases. Under these restrictions, the United States Department of Agriculture has brought into the country a number of valuable foreign sugarcane varieties without any of the pests and diseases known to be present in the countries of their origin.

Foreign importations are handled by the Department with many precautions. The system may be found described at length in published papers, but it may be mentioned here that after thorough inspection and fungicidal and insecticidal treatment, the importations are first grown under observation for two vegetative generations in the insect-proof greenhouse at Arlington Farm, Va., before any cuttings or "seed" are shipped to the main cane-growing states. A number of other sugarcane-

producing countries have similar quarantine stations, often likewise remote from their cane areas, for the observation of varieties officially introduced.

With these introductory remarks, we may proceed to a discussion of foreign insects and diseases which are a potential hazard to the domestic sugarcane industry.

SUGARCANE INSECTS. In considering how sugarcane insect pests may enter a new country, we must take into account the manner of shipping seeds and cuttings. Sugarcane is, of course, not grown from true seed except for the purpose of originating new varieties. The seeds are minute in size, and with due inspection and fumigation the few insects which they might harbor should easily be eliminated. The cuttings are more difficult to handle. In all commercial plantings and in most experimental ones sections of the stalk are planted. These are ordinarily planted with the leaf-sheaths adhering to the stalks to protect the lateral buds or "eyes." In shipping cane from country to country, however, these leaf-sheaths should be carefully removed, the cuttings should be inspected, and it would be advisable to wash them in a strong solution of fish-oil soap.

It will be seen that with these practices the cuttings should be received practically free of insects. The soil insects can not be present, because no soil is shipped. The leaf insects are likewise absent, as the cuttings are freed of both leaves and leaf-sheaths.

The dangerous insects can only be the species which live within or on the stalk. There are a number of boring moth and weevil larvae, and these are especially to be feared. The larger larvae make holes in the stalks which almost pass unnoticed in a large pile of sugarcane, but which are readily observed when a stalk-by-stalk examination is made. The holes made by smaller larvae are not so easily noticed. The moths deposit their eggs on the leaves, but the weevils insert theirs into the stalk, and it is difficult to say with confidence that a weevil egg is positively not present. The precaution of growing the cane for a while at quarantine stations is therefore very desirable.

A brief review of the principal pests of sugarcane may be worth while. The most injurious pest, considering the many countries which it infests, is undoubtedly the moth borer, *Diatraea saccharalis* F. This, or closely related species, is distributed in all the sugarcane-producing regions of North, South, and Central America and the West Indies. Borers of the same genus occur in Java, India, and elsewhere in the East. The eggs are deposited on the leaves, but practically the entire larval and pupal life is spent in tunnels in the stalk made by the larvae.

The adult moths force their way out of the stalk, and soon deposit more eggs. The boring of the stalk destroys the sugar-producing tissues of the plant. The tonnage of cane and the production of sugar are thus reduced. In Louisiana, it has been estimated that the annual loss is about one-fifth of the crop. The borer not only destroys cane on its own account, but it allows the entrance of diseases (such as red rot) which cause a further reduction of sugar. The moths fly, but the principal mode of distribution to new areas is in the moving of sugarcane by human agencies. It might be mentioned that in Louisiana it has been found that soaking the cane for 20 minutes in water at 50°C. will ordinarily kill all borer larvae and pupae. The exceptions were hibernating larvae, which were not all killed. In other words, the treatment was not quite perfect when conducted during the winter season.

The weevil stalk borers are somewhat similar in habit. Their eggs are deposited in the stalk instead of on the leaves, and with this exception their life histories are about the same as those of the moths. Weevil borers occur both in the Eastern and the Western Hemispheres. The most noteworthy of the stalk-boring weevils is the sugarcane borer of Hawaii, *Rhabdocnemis obscura* Boisd. Uncontrolled, its damage was similar to that of the moth borers. As is well known, however, it was in great part controlled by the introduction of the tachinid fly, *Ceromasia sphenophori* Vill., from New Guinea.

Other insects damage the stalk without boring into it. Such are the mealybugs of several species, a few scales, and some moth larvae called bud worms, which feed on the "eyes," or buds, and on the rind of the stalk. The mealybugs and scales injure the cane, of course, by sucking out the juice. Careful inspection and washing the cuttings in an insectidal solution should eliminate such pests from shipments.

Descending to the roots, we find a number of species of white grubs, especially in Porto Rico. One species (*Phytalis smithi* Arrow) was once transported from Barbados to Mauritius in the soil around potted sugarcane plants. It became established in Mauritius and has since been very troublesome.

Other soil insects are the root weevils of the West Indies (*Diaprepes abbreviatus* L. and others in the same genus). These weevils injure not so much the roots as the rootstocks of sugarcane. One larva has been said to be sufficient to kill a stool of sugarcane.

Quarantine regulations may of course prevent the shipment of soil, and thus soil insects may easily be eliminated in shipments of sugarcane.

As to leaf insects, there are pests both of the gnawing and the sucking kinds. There are several aphids, including the corn leaf aphid (*Aphis*

maidis Fitch), which transmits mosaic disease. Another is the woolly aphid (*Oregma lanigera* Zehnt.) of Java. It is reported that sums of from two to four thousand dollars are spent annually by some planters in the control of this pest. Since large spraying machines can not move about in the dense cane fields, the application of insecticides must be made by hand or with small machines.

There are a few scale insects and these and the leafhoppers suck the juice out of the leaves. An introduced leafhopper (*Perkinsiella saccharicida* Kirk.) in Hawaii has been controlled by introduced parasitic insects, but it is questionable whether it could be controlled as easily in some other country. Even in Hawaii, large areas of sugarcane were destroyed and the sugar industry was threatened with ruin before the leafhopper was brought under subjection.

Then there are several caterpillars, including the southern grass worm or fall army worm (*Laphygma frugiperda* S. & A.), which eat the leaves.

It will be noticed that two Hawaiian insects mentioned have been largely controlled by introduced parasites. This should not lead to the assumption that even if a pest becomes introduced, it can easily be controlled in this way. The parasites were brought to Hawaii at considerable trouble and expense, after great damage to the crop had been suffered, and while achieving commercial control, they do not entirely eradicate the injurious insects.

Sugarcane insects have been largely transported by human agencies, and hence it seems reasonable to hope that with adequate inspection and quarantine, their introduction might be completely prevented. In other words, if sugarcane is allowed to enter a country only through official channels, there is little likelihood of the introduction of injurious insects. What is to be feared most is possible importations of sugarcane made by unauthorized persons, such as planters, and even the smuggling of sugarcane by laborers or others going from place to place. Such unofficial action may result in the establishment of serious pests, both insects and diseases.

SUGARCANE DISEASES. All of the sugarcane diseases now present in the continental United States have, so far as known, apparently long existed here, or were imported with variety introductions before the establishment of the national quarantines. During approximately 150 years following the first introduction of the sugarcane (in 1751), many foreign varieties were imported and of course but few diseases as such were recognized, much less their cause and means of spread. The wonder is that so few came in. The more important of these are the mosaic which from 1918 to 1926, in conjunction with a

series of unfavorable seasons, brought the Louisiana industry to near ruin; root diseases due to various causes; the red rot of the stalk and seed cuttings, caused by the fungus *Colletotrichum falcatum*, Pokkah bong, or top distortion caused by *Fusarium moniliforme;* and the bacterial red stripe (*Phytomonas rubrilineans*).

Unlike many of the insect pests, the cane diseases as a rule can not be detected by mere inspection of the cuttings. Furthermore many of them are not destroyed in cuttings by the soaking in water at 52°C. for 30 minutes, which in most cases kills insects. The diseases are only manifested after the cuttings are sprouted and even then they may sometimes lie dormant in the growing plant, particularly of tolerant varieties, for many months before any outward signs appear. Therefore, in order to avoid the introduction of diseases, the planting material imported from foreign countries by the federal government is, when possible, selected by a pathologist in the country of origin and upon arrival in the United States is again inspected, fumigated, and treated in hot water, and then, as above mentioned, is grown for an extended period in insect-proof greenhouses far removed from any fields of sugarcane.

Foreign Diseases. Although new diseases are continually being reported, particular vigilance should be observed in preventing the establishment here of the following well-known ones the dangerous character of which has been repeatedly demonstrated in various foreign countries. These are sereh, Fiji disease, streak, leaf scald, gummosis, downy mildew, smut, and rust, which may now be briefly described. The fact is emphasized that every one of these major diseases (as well as several minor ones not mentioned) may be introduced with stalk cuttings the mere inspection of which in many cases would not reveal their presence.

Sereh (cause unknown) was noted in Java as early as 1882 and in a few years spread over the entire island, causing perhaps the most devastating cane-disease epidemic in the history of the industry. It has since given trouble in Formosa. In severe form it prevents elongation of the stalks, resulting in a bunchy growth resembling the "sereh" grass of the East Indies from which it derives its name. The plants do not recover so the growing of ratoon crops was abandoned. The disease is transmitted by infected cuttings in which it is often manifested by reddish bundles in the joints as well as profuse aerial roots on the standing stalks. It was finally controlled in Java by an expensive rejuvenating procedure involving production of seed cane in mountain nurseries, and more recently by steeping seed cane in water at 52°C. for 30 minutes, and particularly the breeding of resistant varieties. The P.O.J. varieties

36, 213, 234, and 2725 now grown in the United States are known to be highly resistant to sereh.

Fiji disease (cause unknown) occurs in Fiji, Australia, the Philippines, and New Guinea, and is potentially a more serious hazard to uninvaded countries than sereh owing to the susceptibility of the great majority of commercial sugarcane varieties. It eventually causes a severe dwarfing of the plant but the most characteristic symptom is the presence of minute elongated galls on the under side of the leaves. Diseased seed gives rise to diseased plants but secondary infections often remain latent for long periods without observable symptoms. It is controlled by roguing out diseased plants and by the planting of resistant varieties.

Streak (a virus disease) has only been known since 1925, when it was reported on the Uba variety in South Africa; it has since been identified in Egypt, Mauritius, and India. Streak belongs to the mosaic type but is transmitted from plant to plant by a leafhopper, and results in broken chlorotic lines or stripes on the leaves instead of the mottling characteristic of mosaic. Its importance lies in the susceptibility of varieties of the Chinese type, like Uba, which are very resistant to mosaic. Streak has been intercepted in the Washington quarantine greenhouse on variety importations from India.

Leaf scald (*Bacterium albilineans* Ashby) and gummosis (next considered) have much in common as bacterial vascular diseases. Scald has been reported from Java, Australia, Fiji, Formosa, and the Philippines, and is considered one of the most destructive diseases of sugarcane. In the chronic form, particularly in case of semi-resistant varieties, it has been known to lie dormant for long periods before the characteristic narrow white streaks appear on the leaves. In the acute phase whole plants may suddenly wilt and die when the leaves present a scalded appearance. The disease is transmitted by infected seed cane, contaminated cane knives, and possibly by insects. It attacks a majority of the more valuable cane varieties and where resistant ones can not be substituted, expensive direct control methods, as roguing, isolation of seed plots, etc., are necessary. Scald has also been intercepted in Washington on seed-cane importations from the Orient.

Gummosis (*Bacterium vascularum* (Cobb) Greig-Smith) occurs in Australia, Mauritius, Porto Rico, St. Kitts, Brazil, and Colombia. Its presence in the Western Hemisphere makes it a particularly serious menace to the domestic sugar industry. Fortunately most of our present varieties are known to be resistant and all new ones developed in the future should be tested in Porto Rico or other places for their reaction to this disease which, owing to multiplicity of communications between this country

and the West Indies, may be accidentally introduced at any time. Gummosis is recognized by characteristic yellowish-brown leaf stripes which follow the vascular bundles, and a reddening of the stalk tissues in the joints. In severe infections yellowish gum will exude from the cut ends of diseased stalks and even pockets of gum may be found on splitting the cane. This gum causes much trouble and heavy sucrose losses in the factory. Considering the early introductions of varieties in Louisiana it is remarkable that this disease has not also been imported.

Downy mildew (*Sclerospora sacchari* Miy.) has been reported from Fiji, Australia, and Formosa, where it often causes serious losses on poor or badly tilled land and especially on poorly drained soils. It is most destructive to ratoon crops. It is readily recognized by the whitening of the upper surfaces of the leaves, which later turn brownish and often split, giving a shredded appearance. Occasional plants are stimulated to abnormal elongation as if they were about to arrow and these stand out like flags above the rest of the field. Millions of spores are formed on the surfaces of the leaves which are readily blown by the wind, spreading the disease with great rapidity during warm rainy periods. It is controlled by the use of resistant varieties and by seed selection and roguing.

Smut (*Ustilago scitaminea* (Rab.) Syd.) has been reported to occur in Formosa, the Philippines, Java, Queensland, Mauritius, India, Natal, and British Guiana. It is particularly destructive to the slender canes of India, from one of which our P. O. J. varieties were derived, and one of the latter (P. O. J. 36) was so severely damaged in that country that it had to be discarded. Varieties of the Chinese type, to which our syrup-producing variety Cayana belongs, are also susceptible as well as a few varieties of the so-called "Noble," or tropical, type. Infected plants are severely stunted, the terminal bud later developing a smut whip made up of a black mass of spores which are readily scattered by the wind. The disease is also carried by infected cuttings and, although its symptoms are easily detected, its rapid means of spread and the known susceptibility of our commercial varieties make it a serious menace to the domestic sugar industry.

Rust (*Puccinia kuhnii* (Kr.) Butl.) is apparently limited to Australia, Fiji, Formosa, Java, the Philippines, and India. It causes minute, yellowish, elongated spots on the leaves where the spores are formed and may be scattered by the wind. It attacks a wide diversity of varieties including the wild cane, *Saccharum spontaneum*. Extensive damage by rust has been rare, but its potentialities have been demonstrated in Fiji on certain seedlings.

In addition to the above there are a large number of so-called minor diseases which have not been observed in the United States. Although of little importance abroad, our varieties might prove more susceptible and these diseases become of major importance if introduced here.

BAGASSE AS A CARRIER OF INSECTS AND DISEASES. The fibrous material which is left after the juice is pressed out of sugarcane stalks is called bagasse. This is an article of increasing importance in commerce. It is now being manufactured into wall board and has been used experimentally at least for several other purposes. At least one shipload has come from Cuba to the United States. The question arises as to whether insects and diseases can survive the milling process or might otherwise be imported as accidental contaminants on the bales of bagasse.

All insects in the sugarcane stalks which pass between the many rollers of a modern sugar mill are killed. The sugarcane is not only subjected to great pressure, but the bagasse is baled for shipment. The only insects on bagasse would be those which might find their way on to it on leaving the factory and the baling press. In other words, insects might be carried on bagasse just as they might be carried on bales of hay or bales of cotton. The writers are of the opinion that the danger of introducing them is slight.

As for diseases, there is probably danger of importations in many cases, not only as contaminants on the bales of bagasse, but from actual survival from the milling process. The ordinary pressures employed would certainly not kill all the bacteria nor even fungus parasites, especially the resistant spores. Hot maceration, used by some mills, appears at first sight sufficient to destroy all life in the material, but careful examination indicates this is probably only partially effective. The considerable thickness of the bagasse blanket, its comparative dryness and therefore heat-insulating properties, and the very short time for its passage from one set of rolls to the next probably does not allow sufficient penetration of the hot water to completely eradicate disease organisms.

CONCLUSION. This brief review is believed sufficient to illustrate the great good fortune of our local industry in having so few of the world's destructive sugarcane insects and diseases. The rapid advancement and future prosperity of the domestic industry will depend to a great extent on our success in keeping them out. This can only be done by the strictest enforcement of the national quarantine and the closest cooperation on the part of everyone in preventing surreptitious importations of varieties. Pathologists and entomologists should be notified of suspicious

disease symptoms and unfamiliar insects observed in the growing crop so that any new trouble may be quickly discovered and eradicated before it becomes permanently established and eradication is no longer possible.

FIFTY YEARS OF PLANT QUARANTINE ACTIVITY IN CALIFORNIA

By A. C. FLEURY, *Chief Quarantine Officer*

ABSTRACT

The first legislation in the United States directing the principles of quarantine against plant pests was enacted in California fifty years ago. This early legislation is discussed and the plant quarantine developments and problems in enforcement in California to the present are briefly sketched.

California modestly accepts credit for being the first state in the United States to enact a law directing the principles of quarantine against plant pests. This law became effective March 4, 1881, fifty years ago. The conditions that brought about this quarantine legislation are interesting. This law was the direct result of the vigorous activities of practical minded grape growers of California, who were very much concerned over the increasing losses occasioned by the aphid, *Phylloxera vastatrix*. A state law providing for the appointment of a Board of State Viticultural Commissioners had been passed by the legislature and approved April 5, 1880. The duties of this board were to promote and encourage the progress of the viticultural interests of the state through the dissemination of educational advice to growers on methods of culture, pruning, fertilizing, fermenting, distilling and rectifying, treating diseases of the vine, raisin drying, etc. This was the first legally authorized agricultural body in the state and, therefore when in 1881, it was determined that quarantine measures to prevent the further spread of Phylloxera were necessary, the administration of same was made a part of the duties of this Board of State Viticultural Commissioners.

At about the same time, there was considerable activity on the part of fruit growers other than grape producers, for a board which would be representative of horticulture in general and not limited to the viticultural industry. This agitation was fostered particularly by the apple growers who were alarmed over the injury occasioned by the codling moth and its spread throughout the state. This agitation on the part of the fruit interests resulted in the passage of a compromise bill by the legislature, approved on March 4, 1881, which represents the first

quarantine legislation in the United States. Because of its historical interest, that portion of this bill which refers particularly to quarantine is quoted herewith in part:

"Sec. 3. The Viticultural Health Officer shall have power, subject to the approval of the Board, to prevent the spread of vine diseases and vine pests, by declaring and enforcing rules and regulations in the nature of quarantine, to govern the manner of, restrain, or prohibit the importation into the State, and the distribution and disposal within the State, of all vines, vine cuttings, debris of vineyards, empty fruit boxes, or other material on or by which the contagion of vine diseases and germs of vine pests may be introduced into the State, or transported from place to place within the State; to declare and enforce regulations approved by the Board for the disinfection of vines, vine cuttings, vineyard debris, empty fruit boxes, and other suspected material dangerous to vineyards, while in transit, or about to be distributed, or transported into, or within the State; to classify the vineyards and viticultural regions of the State, according to the degree of health, or vine disease prevailing therein, and to change the same as circumstances may require to be done, subjecting each class to such varying rules and regulations, respecting the introduction or transportation of vines, vine cuttings, and other material liable to spread contagion of disease among vines, as may, in the opinion of the Board, become necessary and expedient for the preservation of vineyards. Such rules and regulations shall be circulated in printed form by the Board among the vine growers and fruit dealers of the State, shall be published at least thirty days in two daily newspapers of general circulation in the State, not of the same city or county, and shall be posted in a conspicuous place at the county seat of each county affected by their provisions.

"Sec. 4. The Viticultural Health Officer may appoint local resident Inspectors in any and all of the viticultural regions of the State, whose duties shall be to report to him concerning the health of grapevines, the progress of vine diseases and pests, and all violations of the rules and regulations of the Board; to certify to the proper disinfection of vines, vine cuttings, empty fruit boxes, and other transportable articles required by the Board to be disinfected before transportation, or while in transit, or after delivery at any point of destination, the methods of disinfection to be determined and approved by the Health Officer and the Board; to sieze upon and destroy all vines, vine cuttings, debris of vineyards, empty fruit boxes, and other material liable to spread contagion, which may be found in transit, or delivered after transportation, not certified to as required by the Board; provided, that the same may be exempt from such destruction if the cost of disinfection by such Inspector shall be provided for by the owner or agent in charge thereof, as may be prescribed for such cases or negligence, carelessness, or violation of quarantine rules, and to keep a record of all proceedings as such Inspectors; provided, that there shall be no compensation for such services of inspection, excepting a fee, not to exceed one dollar for each certificate of disinfection, in case of compliance with quarantine regulations, and not to exceed five dollars for each certificate of disinfection after seizure for non-compliance. All vines, or other articles absolutely prohibited of importation or transportation, may be promptly destroyed by any Inspector discovering the same transported or in transit, in violation of regulations, and the cost of such seizure, together with a fee of ten dollars, shall be paid to such Inspector out of any fine that may be collected from the party or parties guilty of such violation. Wilful violation of the quarantine regulations of the Board shall be con-

sidered a misdemeanor, and punishable by a fine of not less than twenty-five nor more than one hundred dollars.

"Sec. 8. The Board of State Viticultural Commissioners shall also appoint an officer, who shall be especially qualified by practical experience in horticulture for the duties of his office, to perform similar duties respecting the protection of fruit and fruit trees as are provided for in this Act in reference to grapevines, with like powers; and the salary and traveling expenses of such officer shall be fixed by the said Board at the same amounts provided for in the case of the Chief Executive Viticultural Officer; and the said Board shall have power to establish such quarantine rules and regulations as are required for the protection of fruit and fruit trees from the spread of insect pests."

In light of our present day knowledge of plant quarantine principles and legal limitations, some of these provisions are intensely interesting. This Act provided for a legally appointed Viticultural Health Officer and a Horticultural Health Officer with authority to promulgate and enforce quarantine rules and regulations. Section 8, as quoted above, represented the compromised measure to satisfy the Horticultural interests not concerned with grape production although the enforcement was under the direction of a Viticultural Commission, the membership of which was limited to persons interested in the grape industry. Under the authority provided in this Act, Matthew Cooke was appointed Chief Executive Horticultural and Health Officer of the Board of State Viticultural Commissioners, and effective January 1, 1882, he issued "Quarantine Rules and Regulations for the Protection of Fruit and Fruit Trees," which provided that no trees or plants or cuttings thereof or fruits known to be infested with injurious insects, should be moved from any premises within the state until disinfected by dipping in a solution of not less than one pound of concentrated lye to two gallons of water; that all trees and plants and cuttings thereof, imported or brought into California from any other state or from a foreign country, should be disinfected immediately upon arrival unless inspection by the proper quarantine official indicated same to be free from infestation; that fruits imported or brought into the state from a foreign country or from some other state, infested with injurious insects, were prohibited from being offered for sale, gift, distribution, or transportation; that fruits infested with codling moth were prohibited from being kept, used, or moved for any purpose; that used fruit boxes and like containers were required to be disinfected by immersion in a solution of lye and boiling water for two minutes; and that citrus and deciduous fruits infested with any species of scale were prohibited from moving from the premises where grown until washed with a solution composed of one pound of whale oil soap, one-quarter pound of flowers of sulphur, to one and one-quarter gallons of water.

Effective the same date, the Viticultural Health Officer issued Quarantine Rules and Regulations for the Protection of the Grape Industry, which provided that all rooted grape vines and cuttings imported from any point outside the state, and all containers and packing materials accompanying same, must be disinfected by one of six methods, at the option of the owner. The sum of knowledge of insecticides at that date is indicated by these treatment requirements and should be of interest to the entomologist of today. They comprised immersion for varying periods in a solution of one of the following:

(a) 10 pounds Sulpho-carbonate or potash, to 100 gallons cold water;
(b) 1 gallon phenyle to 50 gallons cold water;
(c) A complicated solution of coal tar, carbonate of soda, and water;
(d) 1 pound carbolic acid to 20 gallons water;
(e) 1 pound sulphide of potash to 20 gallons water;
(f) 1 part "liver of lime" to 20 parts water.

The value of these remedial measures was seriously questioned by some and the restrictions imposed by this law were apparently not always accepted with equanimity on the part of those affected. In fact, such vigorous criticism occasionally tending on the discourteous, seemed to be indulged in, that the Chief Viticultural Officer was aroused to a comment which indicates that human nature was then much as it is today and that the position of a quarantine official was even then no sinecure. He stated, "It is probably undignified to refer to such coarse and brutal criticisms; but whenever public sentiment shall become so corrupted that honest gentlemen cannot occupy positions of public trust and confidence without suffering from such barbarous and brutal assaults, and without privilege of reply, I shall be the first to decline to serve the public in any capacity."

That favorable public sentiment was just as essential to successful law enforcement in those pioneer days as it is today, was evidenced by the lack of adequate results accomplished by the Chief Horticultural Officer in attempting to enforce his own regulations. Public sentiment, generally, was against him. While the farsighted fruit grower of that date recognized the importance of pest suppression, he was in the minority. The average fruit producer had little understanding of this subject and unless his interest had been aroused because it was his vineyard or orchard that was dying from insect attack, he was apt to be critical, particularly of those restrictions which affected his personal desires. It is significant to note that the major criticism at that time was instituted by fruit dealers and was directed against the ruling pro-

mulgated to require the disinfection of all second hand fruit boxes and containers. This matter was finally taken into court and in January, 1883, the State Supreme Court rendered a decision holding that the law which conferred upon an officer the power of declaring what acts should constitute a misdemeanor, was unconstitutional as it virtually amounted to a delegation of legislative power. This brought about the abandonment of quarantine enforcement in California for a short period and in the end proved to be a fortunate occurrence for it brought home to the horticultural interests in the state, the necessity for a legally constituted state body interested in the entire horticultural industry. As merely a branch of the Board of Viticultural Commissioners without legal status, they were impotent to meet the problems of the horticulturists. At this time, there was a rapid dissemination over the state, of codling moth, San Jose scale, peach twig borer, red scale, and cottony cushion scale, and the future development and welfare of the fruit industry were dependent upon effective control of these pests and the enforcement of adequate restrictions to repel the invasion of other and possibly more serious pests which were constantly threatening to become established.

In March of 1883, the State Board of Horticulture was created by the legislature and the act which created this Board, provided for an inspector of Fruit Pests with authority to enforce the regulations of the Board to prevent the spread of fruit pests and diseases of trees and plants, injurious to the horticultural industry of the state. Here for the first time is mentioned plant diseases in connection with quarantine restrictions. The regulations promulgated were by no means drastic but a foundation was laid for future development along pest suppression lines. So far, all quarantine regulations had indicated a decided lack of knowledge of the various avenues by which plant pests might be introduced and spread.

During the years that followed, research has increased the knowledge of life history and host relations of insect pests and plant diseases; competent surveys have brought about accurate determination of pest distribution; and studies on the effects of chemicals, gases, and mechanical appliances have materially modernized methods and procedures directed toward accomplishment of plant, tree, and nursery stock sanitation. These factors have in large part resulted in more lenient and logical plant quarantine practices.

In January, 1912, the State Quarantine Law was passed and it is important to note that this law, after nearly twenty years of active enforcement, is still on our statute books without modification, amendment, or the change of a single word or sentence since its original pro-

mulgation. This law is our basic inspection law and provides that all plants and plant products, including fruits and vegetables, shipped or otherwise transported into this state, must be held upon arrival until inspected for the presence of injurious pests. It further provides the necessary authority for disposition of any such plant material brought into this state so infested or infected. This law specifically prohibits the admission into California, of animals injurious to agriculture; all hosts of any species of the fruit fly family Trypetidae from any country or locality where such fruit fly species exists; and all hosts of peach yellows and contagious peach rosette, and litttle peach diseases, from any state or locality where these diseases are known to occur.

These specific embargoes against fruit flies and peach diseases indicated particular pests which were the subjects of much concern among fruit growers at the time this Act was approved. As a matter of fact, this law was passed at a special session of the legislature called by the Governor to consider legislation which would adequately cover the menace presented by the frequent shipment to the California mainland, of Mediterranean fruit fly infested fruits from the Hawaiian Islands, in which islands that pest had but shortly before been discovered.

In addition to this basic inspection act, authority is provided in another section of the California Political Code, for the promulgation by the Director of Agriculture, of specific quarantines at the boundaries of the state or elsewhere within the state, to prevent the introduction and distribution of insects and diseases injurious to agriculture. It is under this authority that the quarantine orders of the State of California are issued.

The quarantine problems of fifty years ago are memories, but in their stead new problems have arisen which seem far more complicated and difficult of solution. These present difficulties in quarantine enforcement are largely the result of modern improvements and developments in transportation methods, although a gradual elimination of such natural barriers as deserts or barren wastes through the construction of new irrigation projects to put these areas under cultivation, has materially increased the opportunity for the development and spread of the pests. Improvements in motor vehicles, speeding of ocean transportation, improvements in roads, construction of harbors, extension of railroads, and improvement in refrigeration facilities on ships have opened new avenues for possible pest introduction. The expanse of air transportation providing for the rapid transport of perishable merchandise, presents a quarantine problem difficult of solution.

California is particularly fortunate from a plant quarantine enforcement angle, as this state is entirely bounded by mountains, deserts, or ocean, which have to a large degree, prevented pest spread into this state by natural means, and commerce has been limited to definite points of entry where quarantine control is possible. All highways leading into the state are now covered by plant quarantine stations where all vehicles and their contents are inspected. Quarantine inspectors are available at all railroad stations, express depots, and terminal post-offices for the inspection of plants and plant products moving by common carrier. Quarantine inspectors are stationed at all maritime ports of entry for the inspection of ships and their contents.

Regardless of this elaborate protective system, satisfactory protection will not be forthcoming unless public support is secured. Any protective program based on "thou shalt" methods will fail. People must be tactfully educated to the importance of quarantine protection regardless of whether or not they are directly interested in agriculture. The securing of favorable public opinion rests in large part upon the fairness and necessity of the law, and plant quarantine officials alone are responsible for quarantine restrictions being founded upon these necessary factors. Public approval will result in willing compliance. Without this willingness on the part of the public to observe quarantine regulations, the desired protection will be secured only with the greatest difficulty.

THE RELATION OF HYDROCYANIC ACID GAS CONCENTRATION TO THE KILL OF VARIOUS STAGES OF THE BLACKFLY (*ALEUROCANTHUS WOGLUMI* ASHBY)

By A. F. Camp, *Horticulturist, State Plant Board of Florida*, and R. J. Wilmot, *Special Investigator, Fumigation Experiments, State Plant Board of Florida*

Abstract

Experiments were carried on in Cuba using a twenty cubic foot fumigation box, in which the temperature was controlled on the relation of gas concentration to the kill of blackfly (*Aleurocanthus woglumii* Ashby). It was found that, at a temperature of 85°–90°F., 100% control of larvae or pupae was obtained with an exposure of 10 minutes to a concentration of .17–.19% HCN. Adults were completely controlled with a 10-minute exposure to a concentration of .03% HCN. The lower stages were exposed *in situ* on orange, lime, or grapefruit twigs or orange plants.

In connection with the fumigation research work carried on by the State Plant Board of Florida it has been necessary to collect a con-

siderable amount of information concerning the concentrations of hydrocyanic acid gas in air necessary to kill various insects. The information thus collected is distinct and different from the information, ordinarily available in the literature, dealing with the effect of the dosage of hydrocyanic acid (1). This material will be published in a series of papers, the first two of which will deal with two insects of interest to all southern agriculturists though they are not yet known to be present in continental United States. These two insects are the Blackfly (*Aleurocanthus woglumi* Ashby) and the Green Scale (*Coccus viridis* (Green)).

The work here reported was carried on in Cuba during the spring of 1931 as the result of a cooperative agreement between the Department of Agriculture of Cuba and the State Plant Board of Florida. Senor Ernesto Sanchez Estrada, Chief of the Sanidad Vegetal, very kindly arranged with the officials at the Agricultural Experiment Station at Santiago de las Vegas for laboratory and office space and for the necessary facilities for carrying on the work. We wish to express our very great appreciation for the assistance rendered by General Eugenio Molinet, Secretary of Commerce, Labor and Agriculture, Senor Ernesto Sanchez Estrada; Senor A. Portuondo, Director of the Agricultural Experiment Station; Mr. S. C. Bruner, Chief of the Department of Plant Pathology and Entomology; Dr. Bonazzi, Director of the Department of Chemistry; and to Messrs. P. A. Berry and J. M. McGough, of the Bureau of Entomology, of the United States Department of Agriculture. All of the above, together with a number of others, aided the work in every way and, without their very kind assistance, the carrying on of the work would have been impossible.

METHODS. The twenty cubic foot fumigation chamber previously described by Camp and Wilmot (1) was transported to Cuba and set up in the Sugar Cane Research Building at the Experiment Station at Santiago de las Vegas. This chamber has no door and the lower edges run in a deep moat of oil. The chamber is suspended on pulleys, using a counterweight, so that the gas pressure in the box can be adjusted by means of a manometer to compensate for samples removed, changes in temperature, etc. It is equipped with thermostatically controlled heating coils and a fan to properly agitate the air. Liquid hydrocyanic acid is introduced by means of an accurately calibrated burette to give the desired concentration. The entire box is raised clear of the oil moat for the introduction or removal of material for fumigation.

In accordance with all previous work gas samples were withdrawn and analyzed for per cent of hydrocyanic acid at ten minute intervals

during the duration of each experiment. With small amounts of material in the box the concentration remained almost constant but where potted plants were included there was some falling off in concentration due to absorption (1). In Fig. 29 is shown a typical record of one experiment and the small variation in concentration of hydrocyanic acid gas as determined by analysis.

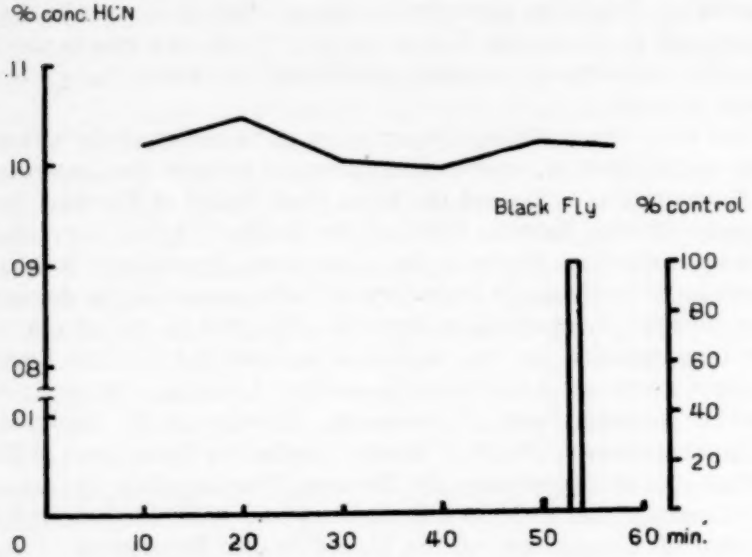

FIG. 29.—Typical laboratory record of one of the experiments. Note the slight variation in hydrocyanic acid concentration as determined by analyses.

All of the experiments were run within a temperature range of from 85–90°F., the weather being such that the maintenance of temperatures below this range would require artificial refrigeration.

Owing to the comparatively short time available, it was necessary to do much of the work with the immature stages of insects on infested twigs removed from the plant. Most of the twigs were from infested citrus trees, chiefly orange and lime. These twigs were removed from the plant with leaves in place and placed with their stems in water. For the period of fumigation the twig was removed from the water and after fumigation the stem was recut and the twig replaced in the water. This was necessary on account of the absorption of hydrocyanic acid by the water when jars containing water and twigs were placed in the fumigation chamber. Owing to the fact that the twigs would not keep

indefinitely, it was necessary to make the counts to determine the kill after short periods of two or three days and some difficulty was experienced in doing this with absolute accuracy. For the eggs and the first larval stages the work was carried out on potted citrus plants furnished by Mr. Berry and the kill of eggs determined by the hatch obtained. For each experiment with immature stages approximately 1,000 individuals were counted and unfumigated checks were kept on all material. The material was always more or less mixed as regards stages of development and the counts were made on the material as it occurred rather than attempting to separate the counts on different forms. The latter procedure would have been desirable had time been available. The kill of eggs and first stage larvae was determined by emergence on fumigated potted plants. Wherever possible the counts were made to include at least 1,000 individuals. In the tables that accompany the charts will be found notes concerning the character of the material used in each experiment.

The adults were exposed in short glass tubes inserted in the suction line to the sampling bulbs and the flow through the bulbs was adjusted to give the time of exposure desired. This procedure caused a slight variation in the total amount of gas passed over the insect but did not introduce an appreciable error. Immediately after exposure to the gas two liters of air were drawn thru the tube to remove the hydrocyanic acid. Some difficulty was experienced in handling the adults and the death rate in the checks in the first experiments was very high so that some of the results had to be discarded.

The per cent control was calculated from the formula (2):

$$\frac{\text{(per cent alive in check)—(per cent alive in treated lot)}}{\text{(per cent alive in check)}} \times 100 = \text{per cent control}$$

Fundamentally we were interested only in a 100% kill so that this is particularly stressed in the interpretation of the data. The results of the experiments are grouped by concentration, thus all experiments within a narrow range of gas concentration are considered together. The tables are self-explanatory.

Discussion of Data. The data covering eggs, larvae and pupae are shown in Table 1. In examining the table particular attention should be given to the effect of the time factor. It will be noted that in no case was a 5 minute exposure effective at any of the concentrations used. It may, therefore, be concluded that even with a concentration of .3%, 5 minutes is too short an exposure.

With one exception a concentration of .1% for ten minutes or more

TABLE 1. PER CENT CONTROL OBTAINED BY EXPOSING IMMATURE STAGES OF BLACKFLY (*Aleurocanthus woglumi* ASHBY) TO VARIOUS CONCENTRATIONS OF HYDROCYANIC ACID GAS. RESULTS GROUPED ACCORDING TO CONCENTRATION USED

Lot	Date	Mean Conc.	Exposure	Percent Control	Host Material	Remarks
			.04–.06% HCN			
15	4– 8–31	.0585	10 min.	49.64	Twigs	All stages
				94.20		Eggs
16	4– 8–31	.0629	15 "	95.39	Plant	Larvae
33	4–23–31	.0419	30 "	98.01	Plant	All stages
18	4– 8–31	.0444	30 "	100.00	Plant	Eggs
19	4–13–31	.0645	30 "	97.12	Plant	All stages
25	4–15–31	.0474	1 hour	99.61	Twigs	All stages
57	5– 6–31	.0505	1 "	99.41	Twigs	Mostly pupae
30	4–20–31	.0545	1 "	100.00	Plant	All stages
54	5– 5–31	.0675	1 "	99.78	Twigs	All stages
			.08–.09% HCN			
14	4– 8–31	.0878	15 min.	80.50	Twigs	All stages
31	4–20–31	.0870	30 "	100.00	Plant	All stages
21	4–13–31	.0912	30 "	97.58	Twigs	Mostly pupae
				97.79		
32	4–21–31	.0966	30 "	100.00	Plant	All stages
28	4–17–31	.0961	30 "	99.12	Twigs	All stages
58	5–12–31	.0814	1 hour	100.00	Twigs	All stages
38	4–25–31	.0928	1 "	100.00	Twigs	Mostly pupae
			.10–.11% HCN			
59	5–13–31	.1180	30 min.	100.00	Plant	Mostly pupae
56	5– 5–31	.1015	1 hour	100.00	Twigs	All stages
			.14% HCN			
50	5– 2–31	.1432	20 min.	99.20	Twigs	All stages
49	5– 1–31	.1441	30 "	99.19	Twigs	All stages
			.17–.19% HCN			
11	4– 7–31	.1953	5 min.	75.21	Twigs	All stages
5	4– 3–31	.1967	10 "	100.00	Twigs	All stages
23	4–13–31	.1931	20 "	100.00	Leaves	Pupae
46	4–29–31	.1979	20 "	100.00	Twigs	All stages
42	4–27–31	.1878	30 "	100.00	Twigs	All stages
36	4–25–31	.1957	30 min.	94.50	Twigs*	Mostly pupae
40	4–27–31	.1766	40 "	100.00	Twigs	Mostly pupae
1	4– 1–31	.1880	1 hour	100.00	Twigs	All stages
2	4– 2–31	.1901	1 "	100.00	Twigs	All stages
			.20–.23% HCN			
13	4– 7–31	.2022	5 min.	88.58	Twigs	All stages
44	4–28–31	.2019	30 "	100.00	Twigs	All stages
48	4–30–31	.2377	30 "	100.00	Twigs	All stages
			.30% HCN			
27	4–17–31	.3035	5 min.	86.20	Twigs	All stages
			.38% HCN			
3	4– 3–31	.3828	10 min.	100.00	Twigs	All stages
4	4– 3–31	.3800	15 "	100.00	Twigs	All stages

*In most of the experiments citrus twigs (with leaves attached) were used, chiefly sweet orange and lime.

gave 100% control. See Table 1, lot 36, under .17 – .19% concentration. The irregularity in lot 36 may be explained partially by the fact that when the experiments were first started liquid hydrocyanic acid was removed from the cylinder into a bottle of 1 gallon capacity, for easier handling. As the air temperature was almost constantly above

TABLE 2. PER CENT CONTROL OBTAINED BY SUBJECTING ADULT BLACKFLIES TO LOW CONCENTRATIONS OF HCN (.0225-.0312%) FOR FROM 2 MINUTES TO 10 MINUTES*

Time	Tube No.	No. of Insects*	Minutes Exposed	Volume of Gas	% Conc. HCN	9:30AM5/8 A	SM	D	Per cent Dead	Per cent Control
2:05	1	24	2.0	2000	.0293	3	0	21	87.50	11.91
2:10	2	33	3.0	2000	.0299	0	0	33	100.00	100.00
2:14	3	26	4.0	2000	.0306	1	0	25	92.30	45.79
2:24	4	40	4.5	2000	.0250	0	0	40	100.00	100.00
ck	5	28	ck	—	—	4	3	21	71.42	—
2:31	6	36	5.0	2000	.0275	0	0	36	100.00	100.00
2:39	7	36	5.5	2000	.0312	0	0	36	100.00	100.00
2:48	8	81	6.0	2000	.0292	0	0	81	100.00	100.00
ck	9	16	ck	—	—	4	1	11	68.75	—
2:58	10	35	6.5	2000	.0302	0	0	35	100.00	100.00
3:25	11	18	8.0	2000	.0250	0	0	18	100.00	100.00
3:36	12	30	10.0	2000	.0250	0	0	30	100.00	100.00
ck	13	45	ck	—	—	3	0	42	93.33	—
3:48	14	35	8.0	2000	.0245	0	0	35	100.00	100.00
3:59	15	33	6.0	2000	.0250	0	0	33	100.00	100.00
4:08	16	68	4.0	2000	.0248	6	5	57	83.83	—12.24
ck	17	32	ck	—	—	2	3	27	84.37	—
4:15	18	24	2.0	2000	.0200	0	1	23	95.83	70.60
4:20	19	28	3.0	2000	.0225	0	0	28	100.00	100.00
4:25	20	67	3.5	2000	.0237	2	0	65	97.01	78.99
ck	21	41	ck	—	—	1	2	38	92.68	—
Mean of Checks	162					14	9	139	14.19%	Alive

*These adults were collected on May 7, 1931, at Finca Serafina from fresh young growth upon which the females were laying eggs. There was a preponderance of females. They were collected between 9:00 and 11:00 A. M.

the boiling point of liquid hydrocyanic acid, some gas was lost whenever the pressure was relieved on the bottle by removing the stopper, which occurred several times a day. After a few days it was noted that there seemed to be a falling off in the toxicity of the fumigant, since concentrations which had caused a 100% kill in earlier experiments failed to continue to do so. The bottle was refilled from the cylinder and it was immediately possible to duplicate the results obtained in previous experiments. Subsequently only liquid freshly removed from the cylinder was used and no more difficulty was experienced with irregular results. It is believed that as a result of the boiling some activity of the HCN was lost and this is borne out by other experiments. This is believed to be a very fertile field for further experimental work. This one exception can consequently be discounted since the same time and con-

centration gave 100% kill when hydrocyanic acid was used directly from the cylinder. With this one exception a 100% kill was obtained with all exposures longer than 5 minutes, and with a concentration of .17 to .19% HCN or higher. The results of these experiments show that a concentration of .2% HCN with an exposure of 30 minutes is sufficient

TABLE 3. PER CENT CONTROL OBTAINED BY SUBJECTING ADULT BLACKFLIES TO LOW CONCENTRATIONS (.034–.0643%) OF HCN FOR FROM 2 MINUTES TO 4½ MINUTES*

Time	Tube No.	No. of Insects	Minutes Exposed	Volume of Gas	% Conc. HCN	5–17–31–2 PM A	SM	D	Per cent Dead	Per cent Control
2:10	1	72	2.0	2000	.0403	43	2	27	37.50	—3.69
2:15	2	66	2.0	2000	.0438	33	3	30	45.45	9.37
—	3	57	ck	—	—	22	2	33	57.89	—
2:23	4	67	3.0	2000	.0391	9	5	53	79.10	65.30
2:29	5	57	3.0	2000	.0346	4	5	48	84.21	73.80
—	6	57	ck	—	—	25	5	27	49.12	—
2:35	7	45	4.0	2000	.0396	0	0	45	100.00	100.00
2:42	8	67	4.5	2000	.0440	0	0	67	100.00	100.00
—	9	48	ck	—	—	20	6	22	45.83	—
2:49	10	67	3.5	2000	.0405	0	0	67	100.00	100 00
2:57	11	71	4.0	2000	.0396	0	0	71	100.00	100.00
—	12	87	ck	—	—	67	7	13	14.94	—
3:08	13	58	3.5	2000	.0632	0	0	58	100.00	100.00
3:17	14	105	2.0	2000	.0565	2	2	101	96.19	93.58
—	15	83	ck	—	—	54	4	25	30.12	—
3:22	16	76	2.0	2000	.0618	1	4	71	93.42	89.15
3:29	17	64	2.5	2000	.0643	0	0	64	100.00	100.00
—	18	85	ck	—	—	30	9	46	54.11	—
3:34	19	64	3.0	2000	.0618	0	0	64	100.00	100.00
3:40	20	83	3.5	2000	.0619	0	0	83	100.00	100.00
						Mean of checks			39.81	
									60.19%	Alive

*These adults were collected at Finca Mariana between 9:30 and 10:30 A. M., May 16, 1931. They were clustered on the new growth where the females were starting to lay eggs. Females predominated.

In Lot 9, 6 of 22 dead were ♀ and of 26 live ones 4 were ♂.
" " 12, 2 of 12 " " ♀ " " 74 " " 5 " ♂.
" " 18, 21 " 46 " " ♀ " " 39 " " 2 " ♂.

to kill immature stages of Blackfly. It should be noted, however, that this refers to exposure of the insects themselves and that crated material would require a longer time to allow for penetration.

The results of the experiments with adult Blackflies are shown in Tables 2 and 3 The concentrations necessary to obtain a 100% kill were very low and the time necessary for the exposure was relatively much shorter than for the immature forms. In Table 2 it will be noted that exposures of less than 4 minutes to a concentration of less than .03% failed to give 100% control but that all longer exposures were successful. In the experiments reported in Table 3, using slightly higher concentrations, all exposures of 3½ minutes or longer gave 100% control. Exposures of 5 minutes or more to concentrations of 0.03%

or higher would seem ample and slightly longer exposures to even lower concentration would be effective. Any fumigation that would give 100% kill of the immature forms should kill all adults without difficulty.

SUMMARY. The work here reported shows that immature stages of the Blackfly (*Aleurocanthus woglumi* Ashby) are killed by relatively low concentrations of hydrocyanic acid gas in air at temperatures from 85 to 90°F.; and that adults are killed with even lower concentrations. A concentration of .20% in contact with the insect for a period of 30 minutes gave 100% control of immature stages and concentrations above .03% gave 100% control of adults with exposure of 5 minutes or longer.

BIBLIOGRAPHY

1. CAMP, A. F., and WILMOT, R. J. Fumigation research in Florida. The Monthly Bulletin, State Plant Board of Florida, 15:1–35. (Nos. 5, 6, 7 and 8). 1931.
2. WARDLE, ROBERT A. The problems of applied entomology pp. 145–147. New York. 1929.

THE RELATION OF HYDROCYANIC ACID GAS CONCENTRATION TO THE KILL OF VARIOUS STAGES OF THE GREEN SCALE (*COCCUS VIRIDIS* (GREEN))

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ABSTRACT

Experiments were carried on in Cuba, using a twenty cubic foot fumigation box in which the temperature was controlled, to determine the gas concentration necessary to kill green scale (*Coccus viridis* (Green)). It was found that, at a temperature of 85°–90°F., 1 hour's exposure to concentrations of .04% to .05% HCN gave 100% control. Concentrations of .19% gave 100% control at exposures as low as 5 min. The insects were exposed *in situ* on sapodilla or orange twigs.

This paper is the second of a series dealing with the effect of hydrocyanic acid gas concentration in air mixtures on the kill of various insects. The first paper of the series dealt with the Blackfly (*Aleurocanthus woglumi* Ashby) (1) and this paper reports on work done in Cuba on Green Scale at the same time. This work was carried out through a cooperative agreement between the Department of Agriculture of Cuba and the State Plant Board of Florida. The details of this arrangement are covered in the preceding paper (1) but we would like to call attention again to the fact that the work was made possible through

the unfailing cooperation of the various officials of the Cuban government and particularly of Señor Ernesto Sanchez-Estrada, Chief of the Sanidad Vegetal, and Señor A. Portuondo, Director of the Experiment Station at Santiago de las Vegas.

METHODS. The methods used were the same as those reported on in the previous paper (1) and described more fully in a former publication by the same authors (2). The 20 cubic foot fumigation chamber was used and most of the material consisted of twigs, bearing infested leaves, cut from the plant. Most of this twig material was cut from a Sapodilla tree (*Achras Sapota* L.) in the yard of the laboratory. However, some citrus and other material was used. As the twigs would not keep indefinitely the counts had to be completed within 2 or 3 days. It was found that Green Scale killed by fumigation turned from the bright green of the live insect to a dull green, in a way quite similar to a leaf that has been burned by cyanide. Live scale could also be distinguished by the movement of the body fluid when they were viewed under the microscope. The counts were made on the material as it occurred on the leaf including both crawlers and adults. Had more time been available it would have been desirable to segregate the work on various stages. However, we were interested primarily in obtaining 100% control on all stages so that the counts as made gave satisfactory information. One thousand individuals were usually examined in each fumigated lot and similar counts were made on the checks. Checks were kept on all material and the count made at the same time as that on the fumigated material.

Per cent control is reported according to the formula (3):

$$\frac{\text{(Per cent alive in check)—(Per cent alive in treated lot)}}{\text{(Per cent alive in check)}} \times 100 = \text{per cent control}$$

The results are grouped according to concentration used to facilitate comparison; thus all of the experiments within a narrow range of concentration are reported together and show the variation in results obtained with different lengths of exposure.

DISCUSSION OF DATA. It was found that very low concentrations of hydrocyanic acid gas in air were necessary to obtain a high per cent control. Exposures of thirty minutes to .04 – .05% HCN gave 100% control in one case out of four, and in the other three cases showed a per cent control of 98.99% or better, indicating a high degree of toxicity. One hour at this same concentration gave 100% control in the one instance tried. In one experiment with one hour's exposure at .0298% HCN 100% control was obtained and one hour's exposure to .0235 gave

99.2% control. In all experiments with concentrations of .07% HCN or higher 100% control was obtained. A five minute exposure at .19% HCN gave 100% control though similar exposures with immature Blackfly stages were failures. (1)

TABLE 1. PER CENT CONTROL OBTAINED BY SUBJECTING GREEN SCALE (*Coccus viridis* (GREEN)) TO VARYING CONCENTRATIONS OF HYDROCYANIC ACID GAS IN AIR. DATA GROUPED BY CONCENTRATIONS

Lot	Date	Mean Conc.	Exposure	Per cent Control	Host Material	Remark
			.02–.03% HCN			
34	4–23–31	.0362	40 min.	99.09	Twigs*	All stages
64	5–21–31	.0235	1 hour	99.20	Twigs	All stages
63	5–19–31	.0298	1 hour	100.00	Twigs	All stages
			.04–.05% HCN			
15	4– 8–31	.0585	10 min.	97.25	Twigs	All stages
33	4–23–31	.0419	30 min.	99.88	Plant	All stages
68	5–25–31	.0420	30 min.	98.99	Twigs	All stages
22	4–13–31	.0442	30 min.	99.58	Twigs	All stages
66	5–22–31	.0569	30 min.	100.00	Twigs	All stages
60	5–18–31	.0538	1 hour	100.00	Twigs	All stages
			.07–.09% HCN			
14	4– 8–31	.0878	15 min.	100.00	Twigs	All stages
62	5–18–31	.0798	30 min.	100.00	Twigs	All stages
52	5– 3–31	.0924	30 min.	100.00	Twigs	All stages
			.19% HCN			
11	4– 7–31	.1953	5 min.	100.00	Twigs	All stages
5	4– 3–31	.1967	10 min.	100.00	Twigs	All stages
8	4– 3–31	.1976	10 min.	100.00	Twigs	All stages
2	4– 2–31	.1901	1 hour	100.00	Twigs	All stages
			.20% HCN			
10	4– 3–31	.2007	5 min.	100.00	Twigs	All stages
13	4– 7–31	.2022	5 min.	100.00	Twigs	All stages
			.38% HCN			
3	4– 3–31	.3828	10 min.	100.00	Twigs	All stages
4	4– 3–31	.3800	15 min.	100.00	Twigs	All stages

*Twigs with leaves attached, mostly from Sapodilla.

As compared with Blackfly (*Aleurocanthus woglumi* Ashby) the Green scale is much more easily killed by fumigation with HCN, and any fumigation that will give 100% control of Blackfly larvae or pupae will give 100% control of Green scale. Thus the subjection of infested material to a concentration of .2% would kill both Blackfly and Green Scale.

SUMMARY. In a series of experiments to determine the effect of various concentrations of hydrocyanic acid gas in air on Green Scale (*Coccus viridis* (Green)) it was found that even low concentrations of this gas

were very toxic. Concentrations as low as .08% HCN resulted in 100% kill after exposure to gas for periods as short as 30 minutes. Concentrations of .2% produced 100% kill in 5 minutes.

Bibliography

1. Camp, A. F., and R. J. Wilmot. The relation of hydrocyanic acid concentration to the kill of various forms of the Blackfly (*Aleurocanthus Woglumi* Ashby). Jour. Econ. Ent. (To be pub.)
2. Camp, A. F., and R. J. Wilmot. Fumigation research in Florida. The Monthly Bulletin, State Plant Board of Florida, 15:1–35. Nos. 5, 6, 7 and 8. 1931.
3. Wardle, Robert A. The problems of applied entomology pp. 145–147. New York. 1929.

REPORT OF SECRETARY OF NATIONAL PLANT BOARD

R. W. Leiby, *Secretary*

The members of the Board individually and as committees have been quite active during the past year with many subjects pertaining to plant quarantines. The regular meeting of the Board was held at New Orleans, La., December 29, 1931. The present membership of the Board is as follows: W. C. O'Kane, Chairman and J. F. Adams representing the Eastern Plant Board, A. G. Ruggles and G. A. Dean Vice-Chairman representing the Central Plant Board, A. C. Fleury and George G. Schweis representing the Western Plant Quarantine Board, and M. S. Yeomans and R. W. Leiby Secretary-Treasurer representing the Southern Plant Board.

The most important contribution to plant quarantine work by the National Board has been the set of "Principles of Plant Quarantine" which appeared in printed form during the past year. A copy of these principles is attached to this report. Printed copies of these principles have been sent to all countries engaged in regulatory and control work.

The Board is now engaged in a study of the principles of pest eradication, and is interested also in a set of principles relative to compensation for products condemned through plant quarantines and pest eradication work.

In keeping with its aim, the Board acts in an advisory capacity regarding Federal and State quarantines, and passes upon such matters as are referred to it by the regional boards.

The treasury shows a contribution of $50.00 from each of three regional boards during 1931, and a balance of $331.49. Expenditures during 1931 have amounted to $121.82.

The Principles of Plant Quarantine were also submitted for publication as a part of the report of the Secretary of the National Plant Board.

PRINCIPLES OF PLANT QUARANTINE

1. Definition. A quarantine is a restriction, imposed by duly constituted authorities, whereby the production, movement or existence of plants, plant products, animals, animal products, or any other article or material, or the normal activity of

persons, is brought under regulation, in order that the introduction or spread of a pest may be prevented or limited, or in order that a pest already introduced may be controlled or eradicated, thereby reducing or avoiding losses that would otherwise occur through damage done by the pest or through a continuing cost of control measures.

2. BASIS IN LOGIC. Since the ends to be attained by a quarantine and the measures required by it could not be undertaken by private individuals or groups, involving as they do restrictions on areas, persons, or activities for the benefit of wider interests or the public at large, resort to regulation imposed by public authority is logical.

3. NECESSITY. Establishment of a quarantine should rest on fundamental prerequisites, as follows: (1) the pest concerned must be of such nature as to offer actual or expected threat to substantial interests; (2) the proposed quarantine must represent a necessary or desirable measure for which no other substitute, involving less interference with normal activities, is available; (3) the objective of the quarantine, either for preventing introduction or for limiting spread, must be reasonable of expectation; (4) the economic gains expected must outweigh the cost of administration and the interference with normal activities.

4. LEGAL SANCTION. A quarantine must derive from adequate law and authority and must operate within the provisions of such law.

5. VALIDITY. A quarantine established for the purpose of attaining an objective other than that which it indicates or defines is open to serious criticism, even though the actual objective is itself desirable.

6. PUBLIC NOTICE. If the circumstances will permit, public notice of a proposed quarantine should be given and those interested should be invited to contribute facts in their possession. But if the objective would be defeated by the delay required for such notice and discussion, duly-constituted authorities should assume responsibility for the decision to impose or withhold quarantine action.

7. SCOPE. The extent of restrictions imposed by a quarantine should be only such as are believed necessary to accomplish the desired end, but on the other hand the objective of a quarantine should not be jeopardized by omission of any necessary restriction.

8. RELATION TO ERADICATION. If a quarantine is imposed in order that eradication of a pest from a given area may be undertaken, the restrictions involved may properly be relatively extensive, because of the importance of the objective sought, and because the time through which the quarantine will operate may be expected to be relatively limited.

9. RELATION TO RETARDING SPREAD. If a quarantine is imposed for the purpose of limiting or retarding spread of a pest, but without expectation of eradication, the restrictions imposed should be such as are in line with the objective of the quarantine and should recognize the fact that continuance of the pest in the area where it is established, or possibly its spread in time to new areas, is accepted.

10. COOPERATING AUTHORITIES. Since quarantines usually involve relations between public authorities, such as those of the government of one country with that of another, or of Federal and state governments, or of state government and local authorities, the cooperative relationship that is necessary to adequate enforcement should be clearly recognized and duly provided for.

11. COOPERATION OF THE PUBLIC. Because of the fact that the success of a quarantine requires that its restrictions be fully maintained, it is essential that all persons who are affected by it adhere to its requirements. In order that this end may be attained the administration of a quarantine should seek the intelligent cooper-

ation of the public affected, rather than depend exclusively on police powers, the imposition of penalties, or resort to court action.

12. CLARITY. In order that a quarantine may be administered readily and consistently, it should be designed with care, should be phrased clearly, and should be made as simple as is consistent with legal requirements and the objective to be attained.

13. INFORMATION SERVICE. Since the persons affected by a quarantine may not reasonably be expected to possess full or accurate knowledge of the circumstances that make it necessary, or the nature and importance of the aim sought, and since compliance with quarantine restrictions will be more complete if the objective and plans are understood, measures should be taken to set forth the conditions existing, the means to be employed, and the end to be attained, and these measures should be continued from time to time as the undertaking proceeds toward accomplishment.

14. RESEARCH. If an emergency requires the establishment of a quarantine before satisfactory biological data are available, provision should be made as soon as possible for extending the fund of biological knowledge. The authority that exercises the right to establish a quarantine should command or secure the means for biological research, both in order that the quarantine may be made more efficient, and in order that the restrictions may be lessened where possible. The need for research, however, should not be permitted to delay the establishment of a quarantine believed by authorities to be desirable, thereby jeopardizing the objective that might otherwise have been attained.

15. MODIFICATIONS. As conditions change, or as further facts become available, a quarantine should promptly be modified, either by inclusion of restrictions necessary to its success or by removal of requirements found not to be necessary. The obligation to modify a quarantine as conditions develop is a continuing obligation and should have continuing attention.

16. REPEAL. If a quarantine has attained its objective, or if the progress of events has clearly proved that the desired end is not possible of attainment by the restrictions adopted, the measure should be promptly reconsidered, either with a view to repeal or with intent of substituting other measures.

17. NOTICES TO PARTIES AT INTEREST. Upon establishment of a quarantine, and upon institution of modifications or repeal, notices should be sent to the principal parties at interest, especially to Federal and state authorities and to organizations representing the public involved in the restrictive measures.

EXPLANATORY NOTES ON PRINCIPLES OF PLANT QUARANTINES

(Numbers refer to corresponding paragraphs in statement of Principles)

(1) The purpose of this paragraph is to clarify thought in the minds of the public, to indicate the scope of plant quarantines, and to set forth briefly the what and why of a quarantine.

(2) The logical foundation for quarantine action is defined and attention is directed to the fact that private or group action cannot take the place of a regulation imposed by public authority.

(3) Four substantial prerequisites of quarantine action are set forth. It is believed that these four, as defined, are self-explanatory. Thus, if the pest concerned is not one which offers either actual or expected threat to substantial interests, it should not involve the machinery and restrictions of a quarantine. If some measure is available

and presumably effective which is less costly or burdensome than a quarantine, that measure should be the one adopted. If the quarantine cannot be expected to accomplish anything its promulgation is questionable. If the economic gains from a quarantine are likely to be less than the cost of it, including the economic losses that it occasions, it cannot be defended.

(4) Promulgation of a quarantine which does not have behind it statutes or authority adequate to permit its enforcement is an invitation to annulment. Where such authority does not exist it should be sought.

(5) The purpose of this paragraph is to point out the danger inherent in a quarantine which, though presumably intended for control of a pest or similar purposes, is actually based on another objective, such as furtherance of trade.

(6) The principle is submitted that public notice of a proposed quarantine is desirable when possible, but on the other hand public notice should not be absolutely required, because occasion may arise when to delay until public notice can be given would mean defeat of a critically important objective.

(7) The principle here involved is one of adequate measures to accomplish the necessary end, but along with this the exercise of care not to impose unnecessary restrictions.

(8) and (9) An important distinction is set forth in these two paragraphs. It is submitted that a quarantine based on the hope of actual eradication of a threatening pest may properly involve more severe restrictions than those permissible in a quarantine which can hope only to retard spread. In the former case the objective to be gained is greater, the time through which the measure will prevail is presumably more limited, and the restrictions imposed may legitimately be more severe. In the latter case, the actual objective should be clearly understood and the measures adopted should be such as are allowable in view of the end sought.

(10) The cooperative relationships which are nearly always involved in a quarantine should be recognized and should be provided for in the measures proposed.

(11) The fact is here pointed out that a successful quarantine means complete adherence to its provisions on the part of all concerned. Since usually very large numbers of the public are involved, cooperation of the public should be sought.

(12) Quarantines have a tendency toward complexity. Sometimes this is inevitable. To meet this difficulty special effort should be made to phrase a quarantine order in the clearest and most logical language possible.

(13) The fact is recognized that any quarantine is likely to be criticized from time to time, and sometimes seriously so. Much criticism arises from an imperfect understanding of the objective of the quarantine and the necessity for its provisions. It is submitted, therefore, that constant and consistent effort should be made to keep the public advised as to the actual objectives of a given measure and the reasons why it imposes the restrictions that it involves.

(14) The purpose of this paragraph is to recognize, on the one hand, the fact that very often a quarantine must be set up before even reasonably complete knowledge of the pest concerned is available; and, on the other hand, the fact that study of the pest, and of many other phases of the matter, should go on, in order that wise improvements may be possible. These improvements may consist of additional necessary restrictions not appreciated at the start, or they may include relaxation of certain restrictions not found necessary.

(15) and (16) Just as there should be readiness to take prompt action in imposing restrictions, so also there should be readiness to take equally prompt action in relax-

ing them or repealing them, when the progress of events indicates such changes to be proper and safe.

(17) This is essentially a matter of helpful practice, based on the fact that various parties, including quarantine officers of other jurisdictions, should know promptly of any changes in the quarantine structure.

National Plant Board
Office of Chairman, W. C. O'KANE,
Durham, N. H., July 25, 1931

REPORT OF THE EASTERN PLANT BOARD

By THOMAS J. HEADLEE, *President, New Brunswick, N. J.*

During the past year most of the states forming the Eastern Plant Board territory have found themselves involved in plant quarantines of one sort or another and, consequently, the interest of the membership has turned primarily to such matters. The annual meeting of the Eastern Plant Board, which occurred in New York City on November 18th, 1931, formed a forum for the discussion of the working out of quarantines already in operation, of definite proposals for new quarantines, and of crop parasite organisms against which preventative action should be taken.

The board members have exhibited a conservative attitude toward quarantine action in general, preferring to make changes slowly and then only for the soundest of reasons.

The writer cannot let this occasion pass without expressing the sentiment of the board members relative to the splendid cooperation afforded the Eastern Plant Board by the various officers of the Federal Plant Quarantine and Control Administration. It is felt that the chief of that service has been especially active in this cooperation and it is certain that his activities are deeply appreciated.

REPORT OF THE CENTRAL PLANT BOARD

The seventh annual meeting of the Central Plant Board was held on March 5th and 6th at Urbana, Illinois. Some thirty entomologists and inspectors were in attendance representing 9 of the 13 states comprised by this section of the National Plant Board. The states represented included Indiana, Illinois, Iowa, Kansas, Kentucky, Minnesota, Missouri, Ohio and Wisconsin. The states not included were Michigan, Nebraska, North Dakota and South Dakota.

Following a brief address by the president, Mr. E. L. Chambers of Wisconsin, Professor George A. Dean, representative on the National Plant Board, discussed in detail the many important matters coming up before that board at its annual meeting held in Washington, November 18 and 19 of 1930. The most important among the several matters of direct interest to the Central Plant Board were the endorsement of the advisability of having the alfalfa weevil quarantine placed under the administration of Federal Plant Quarantine and Control Administrations and the revision of the black stem rust quarantine to prevent movement of susceptible varieties of barberries and mahonias into the state carrying on eradication work. Dr. S. B. Fracker, in charge of Domestic Plant Quarantines for the U. S. Department of Agriculture explained the parcel post inspection work and reported on the progress of the various activities of the plant quarantine and control administration.

Professor P. A. Glenn of Illinois opened the discussion of the nursery pests considered of importance in the various states of the Central Plant Board, to which

inspectors of the other states contributed which was followed by a discussion on the subject of standards of tolerance for the more common pests.

Professor Dean of Kansas led a discussion on the question of permitting alfalfa hay from alfalfa weevil areas, to pass through states having alfalfa weevil quarantines and the advisability of a Federal quarantine against the alfalfa weevil. The question of extending the Federal quarantine No. 67 against the phony peach disease also was discussed at length. Other questions included the advisability of the postponement of the date for placing an embargo on the entry of cherry and rose stocks contemplated and the suggestion of the elimination of the lesser bulb fly from consideration from quarantine No. 62.

Dr. L. R. Tehon of Illinois and Dr. Curtiss May of Ohio discussed the newly discovered Dutch Elm disease and other diseases of the elm.

E. L. CHAMBERS

REPORT FOR THE WESTERN PLANT QUARANTINE BOARD

By W. C. JACOBSEN, *Secretary, Sacramento, California*

The 13th annual conference of the Western Plant Quarantine Board was held at Cheyenne, Wyoming, June 18, 19 and 20, 1931, with the excellent cooperation of the Wyoming State Department of Agriculture through the courtesy of Commissioner Oldroyd and State Entomologist, A. G. Stephens.

Discussions were largely confined to important subjects of direct concern to the member states along lines of plant quarantine and pest control. Among them were the following items:

(1) The alfalfa weevil quarantines now in effect were reviewed, special consideration being given to the interstate movement of alfalfa meal, the uniformity in alfalfa weevil quarantine provisions as between the member states and the types of equipment which could be approved for alfalfa meal manufacture. Arrangements were made to contact the Central Western Shippers Advisory Board in order that a better understanding between transportation agencies and quarantine officers could be brought about in connection with restrictions on commodities affected by alfalfa weevil quarantines.

(2) The eradication of Ozonium root rot in two limited areas in California was presented. A method utilizing 1¼ per cent commercial formalin solution injected to a depth of six feet under pressure and into each square foot of soil at the rate of one gallon per cubic foot of soil, the necessary pressure being supplied through the use of ordinary orchard spray rigs equipped with special pipes and nozzles, was explained.

(3) Uniformity in apiary inspection regulations, which has been a subject receiving continued consideration since 1924 particularly with reference to the movement of bees and bee equipment interstate; the proper time for certifying honey out of states having severe winters and the burning program for American foul brood.

The Western Plant Quarantine Board has had a special apiary inspection committee for several years, which has resulted in harmonious viewpoints relative to the necessity of American foul brood eradication and better understanding of interstate regulations.

(4) The importance of rice straw or other dried or cured plants or parts of plants used for packing materials as carriers of insect pests and plant diseases was emphasized.

(5) The endorsement of the Plant Quarantine Principles of the National Plant Board.

(6) Uniformity of terms and provisions of quarantine regulations and orders of the several states, particularly in the interest of shipper quarantine promulgations and a more uniform context.

(7) The black locust borer, *Cyllene robiniae*, as a pest of windbreaks and shelter belts in the Rocky Mountain and intermountain country, where locusts are an important tree for this purpose, was reported on by the representatives of several states.

(8) Recent developments in the treatment of commodities subject to quarantine for the purpose of eliminating pest infestation therein, especially through the use of hot vapor and vacuum fumigation.

(9) The importance of soil, particularly when associated with plants, as a carrier of injurious insect pests and plant diseases. This subject, while up for consideration for several years, is gradually receiving greater attention as soil pests become better known.

(10) A special committee was suggested to undertake an analysis of nursery stock certification, involving a consideration of (a) blanket nursery certification based upon the annual inspection of nurseries; (b) certification of nursery stock shipments as a result of the inspection of the shipment immediately prior to transportation, and (c) the value of destination inspection and whether or not destination inspection should become a uniform policy regardless of whether plant shipments are certified or uncertified.

(11) Because noxious weeds are receiving proper recognition as hosts for injurious insect pests and plant diseases affecting commercial agricultural crops, it was considered advisable to request the U. S. Department of Agriculture to correlate the weed control activities now scattered within that Department and to establish a centralized agency to conduct basic weed control investigations. It is recognized that local problems cannot be solved in this manner but that fundamental research on weed types would be especially helpful and would prevent a great deal of the present duplication in investigations among the several states.

(12) While plant quarantine inspection has been aimed primarily to prevent the introduction of injurious insect pests and plant diseases, it has seemed desirable to give serious consideration to other pests of plant production such as injurious bird, mammal, and molluscan species, which are potential agricultural pests. In this connection, it was recommended that more effective enforcement of the Lacey Act, in preventing the introduction of bird and mammal species, be given consideration by the Secretary of Agriculture with a view to having other inspection agencies at entry ports cooperate in the enforcement of this act.

(13) A representative of the Republic of Mexico reported on pest control and plant quarantine conditions in his country, especially emphasizing the high cost of pest control due to the high import duty on insecticides and fungicides. Plans are under way for the development of the manufacturing of these commodities within the Republic because of the availability of raw materials and thereby eliminate import duties, which, in a large measure, have retarded active pest control cooperation on the part of growers.

(14) In addition to the representative of the Republic of Mexico, who was Pablo H. Hope, Chief Chemist of the Federal Office of Agricultural Defense, representatives from the State of Nebraska, Mr. Gates, and from the State of Texas, J. M. Del Curto, presented problems confronting them in their jurisdictions.

Out of the discussion of the above topics there were several important resolutions and recommendations adopted. Among them the following:

(1) Commendation of the U. S. Department of Agriculture and cooperating agencies for eradication of the Mediterranean fruit fly in Florida.

(2) Petitioning the continuation of an eradication program against pink bollworm of cotton.

(3) Requesting the U. S. Plant Quarantine and Control Administration to call an official hearing for the consideration of restrictions on rice straw and plant materials used as packing from foreign countries.

(4) Recommending to the states comprising the southern and eastern plant quarantine boards that the alfalfa meal restrictions in their alfalfa weevil quarantines be uniform and with conditions similar to those adopted by the Western Plant Quarantine Board.

(5) It was recommended to the National Plant Board that—

(a) The cooperation of the Post Office Department be obtained to provide in the Postal Rules and Regulations a means whereby parcel post shipments of plants would become directly amenable to the quarantine authority of the destination state.

(b) Data from authoritative sources and based upon sound principles of quarantine should be developed for informational purposes and for publication in the interest of pointing out the value and importance of sound quarantine procedure as a pest preventive measure.

(c) A study be made for utilizing materials other than soil for the protection of roots or plants or that treatments be developed for balled plants in order to prevent the carriage of destructive soil infesting pests.

(6) The officers elected for the ensuing year are: A. G. Stephens of Wyoming, Chairman; George L. Knight of Montana, Vice-Chairman; W. C. Jacobsen of California, Secretary, and George G. Schweis of Nevada, Representative to the National Plant Board.

It was decided that the meeting place for the fourteenth annual conference, to be held some time in June, 1932, should be some place in the State of Montana, the place to be designated later.

Section of Apiculture

December 29, 1931

The meeting was called to order by the Chairman of the Section, S. W. Bilsing, at 2:00 P.M. in Committee Room No. 1, Municipal Auditorium, New Orleans, Louisiana.

CHAIRMAN: I wish to appoint two committees—the committee on resolutions to be composed of: Leonard Haseman, Chairman, and A. D. Worthington; and the committee on nominations: R. L. Parker, Chairman and G. E. Marvin. Dr. R. L. Parker will now take the chair.

LEONARD HASEMAN: The resolution committee presents the following resolutions:

RESOLUTIONS

Resolved, That the apicultural section of the American Association of Economic Entomologists thank the local committee for the excellent arrangements made for these meetings.

Resolved, That we extend special thanks to Mr. H. B. Parks for the excellent work he is doing for the advancement of apiculture and for the special pains he was forced to go to in attending the meetings and presenting his paper on "The Changing Honey Flora of the Southwest."

Resolved, That we express our sorrow for the great loss suffered by American apiculture in the death of Mr. Frank Rauschfuss and that copies of this resolution be sent to his family.

LEONARD HASEMAN, *Chairman*
A. D. WORTHINGTON

M. C. TANQUARY: I move the resolutions be adopted. The motion was carried.

CHAIRMAN: I will hear the report of the nominating committee.

R. L. PARKER: The nominating committee recommends E. F. Phillips of Cornell University for Chairman, and E. J. Anderson of the Pennsylvania State College for Secretary.

E. OERTEL: I move the nominees be accepted as recommended and that the secretary cast the vote for them. The motion was carried.

CHAIRMAN: If it is the wish of the members the meeting will adjourn until the time of the next meeting in Atlantic City.

Adjourned, 4:10 p. m.

THE RISE OF BEEKEEPING

By S. W. BILSING, *A. and M. College, College Station, Texas*

Man's association with the honey bee began before the dawn of history. There are few animals which have helped man in such a variety of ways, in his struggle up the long road to reach the pinnacle which we now designate by the term, civilization. Honey was man's chief source of obtaining sugar. Wax served as his medium of exchange; furnished him with an artificial means of illumination; enabled him to develop a system of writing by furnishing a plastic yet semi-permanent substance on which characters could be made with sharp pointed stylets; aided him in painting and sculpture; and by molding it into candles he could worship his deity.

Savage tribes have kept bees ever since man began to record his activities. His first interest in the honey bee, no doubt, was prompted by his craving for sweet substances. Since this was the only readily available source of obtaining something sweet in a concentrated form he early expended his energies in enticing bees to live in hollow logs, perhaps later in earthern vessels or baskets made of grasses. This was the beginning of thousands of years of association during which man's well being was augumented religiously, morally and materially by the honey bee which served him to even a greater degree then than it does today. Just when he became an apiarist would be difficult to learn. Figures of bees appear on Egyptian monuments as early as 3500 B.C. There are also numerous biblical references as well, which leads us to believe that his apiarian tendencies must go back for thousands of years.

Its ability to store honey and produce wax, two substances which were of inestimable value to him, early excited not only his admiration, but also his interest in learning something about them. Because of the many references in the records of the ancients, it would seem that he devoted no small amount of energy to a study of their habits. The ancients seemed to have had some knowledge of parthenogensis in the honey bee since they stated, "The bee is unlike any other animal in that it never mates." This belief must have led to their associating it with their dieties. Many of the gods of the ancients were born of virgins, thus, the bee became the symbol of resurrection and the renewal of life. The industry and self-sacrifice of the honey bee were a marvel to them; hence to them the honey bee became the symbol of industry, purity and chastity.

In the course of time the honey bee became connected with many of their religious beliefs. It played an important part in the lives of the

Egyptian as well as the Roman and Greek divinities. Pausanias, the Greek historian tells us that one of the oldest temples dedicated to Apollo was raised by bees from wax and wings. The mythology of the Romans as well as the Greeks refers to the honey bee. Among the Romans the bee had a divinity of its own, Mellonia. Pan was supposed to have been the guardian of the bees and Virgil tells us that Pan invented a musical instrument which he made of reeds joined together with wax. The early Christians referred to the honey bee as the Maid Servant of the Lord. It was natural for those who believed they were the direct representatives of the various divinities on earth to use the honey bee as their insignia. Thus, it was emblazoned on the crown of the Pharoahs; on the arms of the Pope and on the imperial robes of the Napoleons.

Honey was used in many religious ceremonies. Its preservative qualities were also known to the ancients. The Assyrians and the Persians, as well as the Egyptians at times covered their dead with wax and then placed the bodies in honey.

From the earliest times wax candles were associated with religious ceremonies. That there was some occult mystery connected with the use of wax candles seems evident since all of the early pagan peoples used them in connection with their sacred rites. The persecution of the early Christians compelled them to meet in the catacombs. Here they made use of candles for lighting purposes. Later when they began to build churches they found these sacred edifices so dark that they continued to use wax candles for illumination. This seems to be the origin of the use of wax candles for ritualists purposes which has continued to the present day.

Wax was also used by the ancients in the arts. Pliny tells us that "It was not agreed who was the inventor of the art of painting in wax, some thinking that the credit should be given to Aristides of Thebes who was the first of all painters to give full expression to the mind and passions of man." The painting of ships of war was effected by melting wax colors and putting them on with a brush while still hot. That this method of painting resisted the effects of the elements is attested by the fact that the vast mural paintings taken from the ruined houses of the patricians in Pompeii can still be seen after eighteen centuries.

When a man became famous his figure molded from wax was placed in public buildings. Pliny tells us that Lysistratus was the first to study how to secure a faithful likeness of the person represented. He did this by fitting a plaster mould to the face and then pouring molten wax into the cast.

One of the earliest uses of wax was for making light. The primitive

candle was made by taking the pith of a rush and dipping it in wax. Public lighting was introduced by Constantine in the fourth century when he ordered the entire city of Constantinople to be lighted on Christmas Eve.

Wax was also the medium of exchange. It was customary to impose taxes in wax. It was also the custom of the Romans to exact tribute from the nations which they conquered, in wax.

Another of the uses of wax which seems to have contributed materially to man's progress was his use of it for correspondence and the retention of temporary inscriptions. For this purpose wooden tablets were covered with wax and the characters were traced with metal stylets. The Romans wrote their letters on this tablet and the person receiving the letter smoothed out the wax and sent back their reply on the same sheet.

Thus, it may be seen that in ancient times beekeeping was an important activity of every farmer and afforded no small part of his income. Bees supplied him with honey as well as with wax. Honey, no doubt, satisfied his craving for sweet substances, served him in his sacred rituals and initiations and even in the preservation of his dead. Wax, he used in writing his love letters; in preserving the casts and images of his great men as well as his loved ones; in painting and sculpture; and to his discredit in magic and sorcery as well as in medicine; in paying taxes to his king; and the conqueror in collecting tribute from those whom he vanquished. It furnished him with a method of illumination to dispel the darkness of the long nights. Scarcely without exception it afforded him a means of offering supplication to his deity, whether it were the Egyptians in their worship of Apis, the Zorasterians in their worship of the Sun God, or the celebrations held in Attica in honor of Ceres, the Goddess of Corn. Later, when he believed himself to be the direct representative of his deity on earth, he used the bee as a symbol on his crown, coat of arms or imperial robes, depending on his status in reference to his fellowman.

So, with the passing of the ages, man's knowledge of bees and beekeeping slowly progressed. He invented and discovered many new things and many of the uses he originally had for honey and wax were supplanted by the other things he invented or discovered.

With the invention of printing it was possible to exchange and permanently preserve the information he collected. Between 1568 and 1700, twenty-four publications were issued on beekeeping. In 1845, the first of three great events in modern beekeeping happened. In that year, Dzierzon, a Polish Catholic priest of Karlsmarkt in Silesia, dis-

covered parthenogensis. This was a great step forward, but his views were not readily accepted. When Siebold, Leuckhart, and Leidy, with the aid of the microscope confirmed Dzierzon's discovery a great impetus was given to beekeeping. Although the Egyptians and Babylonians must have had an inkling of this fact, this information evidently was not entirely confirmed or else was lost in the middle ages. This discovery was not only of great importance to beekeeping, but to biological sciences in general. It explained many things that had worried careful observers for a long time.

In 1851, six years after Dzierzon discovered parthenogensis, L. L. Langstroth invented the first practical movable frame hive. It would be difficult to estimate which has had the most influence in the development of beekeeping.

In 1865, Major Hruschka at Dolo, near Venice, Italy discovered that it was possible to throw honey from combs by centrifugal force. From this idea has evolved various types of extractors beginning with the original single frame extractor devised by Major Hruschka to the improved ones of today.

In 1873 Moses Quinby invented the bellows smoker, which has greatly facilitated the handling of bees. The origin of comb foundation seems to have been an evolution of the ideas of several people.

These are a few of the many inventions and discoveries which have linked ancient beekeeping with the beekeeping of today.

Man has studied bees a long time. During that time he has learned much, but he has also contributed to his own difficulties. Primitive man attributed to the honey bee all the virtues except hospitality for he observed that a bee from one colony was not permitted to enter another colony. Since primitive tribes were intent on preserving their tribal integrity they recognized this as an admirable trait. It was also considered as an ill omen to transfer bees from one owner to another. On that account it would be logical to believe that the diseases of bees were not disseminated to a great degree because colonies of bees seldom changed owners. But with the coming of rapid means of transportation, man has spread bee diseases over much of the earth. This in time bids fair to eliminate all but those who are willing not only to acquire a knowledge of bee behavior and bee diseases, but also to put this information into practice.

This, no doubt, will have an important bearing on the future, not only of beekeeping, but also the usefulness of the honey bee in the role of pollination. The importance of the honey bee in this respect is well known to all of us. We have recounted that beekeeping was an impor-

tant activity and furnished an important part of the income of every farmer in ancient Egypt, Greece and Rome.

The wide spread presence of bee diseases, it would seem, will more and more limit the keeping of bees to a smaller number of people. Bees are necessary for the pollination of many kinds of fruits and vegetables. One of the important problems of the future will be to provide a sufficient quantity of bees for pollination at the proper time. Southern beekeepers are able to produce the bees at a minimum cost. Our northern friends tell us they would be glad to get our bees, provided they could depend on us to ship the bees at the time they are most needed. But, when so much is dependent on having bees at the proper time and that time is so limited they can afford to depend only to a limited extent on shipments of bees from the south. If bees can be produced in the south much cheaper than in the north, then it would be to the advantage of both northern and southern beekeepers to arrive at a better understanding of this problem. Perhaps the most limiting factor in the solution of this problem is the high express rates which consumes a large part of the profit of the producer.

One of the most important problems confronting the beekeeping industry is a proper system of marketing. This is a problem which has been discussed a great deal and yet we have not made much progress in its solution. There are so many factors involved that it challenges our best efforts.

In many parts of the south, honey is gathered from a variety of sources and over a long period of time. As a consequence the honey is seldom of the same flavor or color in two successive years. The American consumer has come to demand a standard color and flavor. If some inexpensive process could be devised that would standardize the color of this honey, beekeepers in these localities would not be at a disadvantage as they are at the present time.

Wintering is an expensive problem in many parts of the far north. In most localities of the south, bees can be produced at a small cost. Some data over a long period of time as to whether or not it would be profitable for the northern beekeeper to destroy his bees in the fall and purchase bees from the south is much needed information in beekeeping.

This section began as a section on apiary inspection. The various states have not as yet agreed on any uniform regulations on bee inspection and the treatment of American Foul Brood. Uniform regulations on shipping package bees and queens would also be a desirable improvement.

Sugar is supplied to the American public largely from foreign sources

of production. If sugar can be produced and shipped to this country and refined at a less cost to the consumer than the American beekeeper can afford to take for his product, perhaps we need to further investigate our methods of honey production to see if our present methods can not be improved upon.

In parts of the southwest vast stretches of native plants that are good honey plants are being destroyed to give place to modern agriculture. Are there any plants that can be cultivated profitably to take their place in these regions?

Again and again we hear "That honey is the sugar best adapted to the human digestive system." That being the case, we are doing a great injustice to the human race by not forcing upon them wholesale the consumption of honey. It is needless to say we need more information on the chemistry and the food value of honey as well as on the physical condition.

Genetical studies of the honey bee have been made possible by the recent work in artificial insemination. This is a field well worth exploration and should yield much valuable biological information.

These are but a few of the many questions either awaiting solution or questions on which more information is needed. Beekeeping was one of primitive man's earliest interests. It should be much more interesting today. Its problems are still many and sufficiently varied to challenge the best there is in any of us.

DATA CONCERNING ONE METHOD OF APIARY MANAGEMENT FOR USE IN THE CALIFORNIA BUCKEYE AREA

By F. E. Todd and G. H. Vansell, *Pacific Coast Bee Culture Field Laboratory, U. S. Bureau of Entomology, Davis, Calif.*

Abstract

Beekeepers in the Great Valley of California experience a severe dearth following spring blossoms. The foothills above this valley afford nectar during this time, but because of the poisonous buckeye the colonies cannot be safely located there. Inasmuch as the adult bees are not seriously injured by this poison, the removal, from the valley colonies, of the worker population for use in the storage of buckeye honey is a possibility.

During the manipulation and movement of bees in connection with the testing of hybrid strains in the buckeye belt, the data secured indicated that adult bees are not seriously affected by this poison.[1]

[1]Vansell, G. H., and Todd, F. E. Resistance of hybrid honeybees to a plant poison in California. (See following paper, p. 503.)

This discovery suggested a method whereby it might be possible to obtain buckeye honey without serious loss of colonies.

A severe dearth exists practically throughout the Great Valley of California immediately after the spring flush of wild flowers and fruit blossoms. As normal colonies of bees remaining in the valley through this dearth period rapidly consume their stores, the result is a cessation of brood-rearing and a consequent depletion of their population to such an extent that by the time the cotton, yellow star thistle, blue curl, or alfalfa flows begin no surplus honey can be stored until colony strength is rebuilt on these sources of nectar. At this time the buckeye is available in the belt which encircles the valley on the foothills up to 3,000–4,500 feet elevation.

Package-bee producers in the Sacramento Valley have in recent years been insisting that those colonies from which bees are removed for shipment during the early summer continue to build up in bee population throughout the dearth, provided stores are plentiful, sufficiently to be in storing condition at the beginning of the thistle flow.

EXPERIMENTAL WORK. In the experiment reported here the common shipping practice was simulated by the removal of the greater part of the adult worker population from some colonies in the San Joaquin Valley at the beginning of the buckeye period, the queen being left with a few bees as a nucleus to build up into a full colony for the cotton flow. These queenless "package" bees were placed in hives containing empty drawn combs, with the exception of one frame with normal brood, and were moved into the southern Sierra Nevada foothills, where each unit stored a crop of buckeye honey. About 50 per cent of them succeeded in rearing a "buckeye" queen. Certain data for the buckeye period are shown in Table 1.

TABLE 1. DATA FROM "SURPLUS BEES" IN PRODUCTION OF BUCKEYE HONEY, APRIL 24 TO MAY 26, 1931

Number of units	10
Number of days in the flow	32
Total weight of honey, in pounds:	
At beginning of period	718
At end of period	1,127
Total weight gain, in pounds	409
Average gain per colony, in pounds	40.9
Total weight of bees in the units, in pounds:	
At beginning of period	88
At end of period	52
Average production of honey per pound of bees, in pounds	4.6

After the buckeye flow, which is normally four to six weeks in duration, the honey was extracted from a portion of the colonies. Each

queenless colony was strengthened by the addition of a four-frame nucleus of nonbuckeye bees, with brood and queen, while those colonies which had succeeded in rearing a queen during the buckeye flow were not requeened. The colonies were distributed similarly to the hybrid groups, described in a previous paper, for the recovery tests. During this period another crop of honey was secured, and certain of the colonies came up to wintering strength. Several of the colonies from which the buckeye honey was not removed dwindled to extinction. Bears destroyed all the colonies of a lot at one location (7,600 feet elevation). Table 2 gives certain details of colony performance.

TABLE 2. DATA FROM THE "SURPLUS BEE" COLONIES PLACED, WITHOUT STORES, IN NECTAR AREAS DURING THE RECOVERY PERIOD, JUNE 2 TO JULY 26, 1931

Number of colonies available at end of period	4[1]
Total weight of colonies, in pounds:	
At beginning of period	298½
At end of period	422
Total weight gain[2], in pounds	123½
Average colony gain, in pounds	31
Average gain, in pounds, of three normal colonies	47

[1]The small number of colonies precludes definiteness in conclusions.
[2]One colony, with a queen reared on buckeye flow, failed to resume normal brood rearing and lost 19 pounds in weight.

The valley colonies, though reduced to nuclei by removal of worker bees at the opening of the buckeye flow, recovered to sufficient strength for the storage of honey from the late valley sources. This season, in fact, the colonies so treated produced from cotton and alfalfa at least as much surplus as those from which the excess population was not removed after the orange flow.

CONCLUSION. The removal of surplus bees from valley apiaries for use in storing buckeye honey has been shown to be advantageous from two points of view. First, package bees, with a frame of brood, secure a crop of this honey in the foothills and remain in such condition as to respond satisfactorily upon the addition of normal bees, with brood and queen, after the buckeye flow is over. The buckeye honey must be removed by extraction. Second, the original valley colonies, reduced to nuclei, but having ample stores, breed up during the dearth, so that by midsummer they are in a condition as good as or better than normal colonies from which the spring bees were not removed, and which were not given additional stores.

RESISTANCE OF HYBRID HONEYBEES TO A PLANT POISON IN CALIFORNIA

By G. H. VANSELL and F. E. TODD, *Pacific Coast Bee Culture Field Laboratory, U. S. Bureau of Entomology, Davis, Calif.*

ABSTRACT

The buckeye plant in California, when used as a source of nectar and pollen by bees, seriously handicaps beekeeping endeavors within its range through its poisoning effect upon the colonies. Since success in resisting this poison, through the use of Carniolan x Italian hybrid stock, had been reported by a beekeeper, Carniolan x Italian and Caucasian x Italian F_1 hybrids, as well as other bees, were tested in 1931. Evidence is in favor of the Carniolan x Italian stock, but even these bees were not entirely satisfactory.

The California buckeye (*Aesculus californica*) causes much concern and actual loss to beekeepers within its range. The buckeye stores in the hive are a constant source of danger for an undetermined period, the characteristic symptoms appearing when conditions necessitate consumption. The colonies gradually become depleted of adults because of failure to replace the workers upon their normal death. Entire apiaries may be depleted in population to such an extent that they can not produce surplus honey for the season. In severe cases the colonies gradually die, leaving hives full of honey. Doubtless the severity of the poisoning depends on the proportion of the buckeye to other nectar sources in the area.

Although some buckeye honey has been produced in California since beekeeping began there, no injury to man from its consumption is known.

Earlier publications[1] have given details concerning the effects on the bee colony. Suffice it to say here that the individual bees reared on buckeye products are often seriously affected. Much of the unsealed brood is killed outright, and an attempt is made to rear another set of individuals in the cells thus left empty. This destruction of brood results in a characteristic spotted appearance of the combs, young of all stages being scattered promiscuously throughout the brood area. Certain adults that emerge after receiving buckeye products are undersized; others are unable to fly because their wings expand incompletely, if at all. The "intelligence" of the adults is impaired so that the colony behaves abnormally; upon emerging the bees walk nervously about, leave the hive, and crawl away in the near-by vegetation.

[1]Vansell, G. H. Buckeye poisoning of the honeybee in California. Amer. Bee Jour. 65:575–578. 1925. Buckeye poisoning of the honeybee. Calif. Agr. Expt. Sta. Circ. 301. 1926.

Even if the deleterious material is not sufficiently concentrated to kill adult bees, reproduction is nevertheless affected. In 1931 colonies were observed in which nearly all the eggs, even those in worker cells, gave rise to drones. Certain queens even ceased oviposition. This season the adult worker bees, which were mature when exposed to buckeye, were not seriously affected. Many unstable "shiny" individuals appeared in the colonies, the number increasing as the season progressed; but this condition is now attributed more to age than to buckeye. Nectar and pollen from wild alfalfa (*Lotus scoparius*), which was stimulated by late spring rains, were secured along with those from the buckeye and undoubtedly modified the severity of the buckeye symptoms.

Former observations (1923–1925) in locations where, at times, buckeye was worked exclusively showed that the worker adults were affected in 1924 more severely than in either of the other years. The diseases of adult bees are, however, so difficult to distinguish that part of this trouble may have been due to "paralysis."

One observing beekeeper in the buckeye area, William G. Watkins, has several times reported success in his yards by using a hybrid cross between the Carniolan and Italian races. This man manages regularly to secure good honey crops, whereas others in the same area, using the ordinary strains of the various races of bees, meet with failure. Furthermore, attempts at honey production with the Italians and the Carniolans in his own yards have been unsuccessful. Inquiry revealed the fact that, in addition to using hybrids, he has for a number of years been cutting bee trees in his vicinity and carrying the bees of black stock home to become mixed with his yard stock. That these "wild" black bees had become somewhat resistant by natural selection was a further possibility about which nothing definite was known.

Experimental Work. In an effort to establish some helpful facts concerning this problem of great importance to California beekeeping, certain experimental work with hybrids was outlined and partially completed during the 1931 season.

Commercial strains of various bee races, mostly Italians, had been used in experimental work at the California Experiment Station as early as 1924. Results indicated that none of these bees could stand up through the buckeye flow unless other attractive sources of nectar and pollen in superabundance were within reach.

The hybrid crosses used in the experiment reported here were located in the Sierra Nevada foothills (800 feet elevation) where buckeye was abundant. All the bees were taken in normal condition from an orange district and moved into the buckeye between April 24 and 26. Italian x

Carniolan and Italian x Caucasian F_1 hybrids (with females of Carniolan and Caucasian[2] stock, respectively), as well as a group of badly mixed Italian x ? hybrids, were tested. The records for the third group are not used in this paper. The Carniolan x Italian stock, although affected,

TABLE 1. COMPARATIVE DATA FROM COLONIES OF HYBRIDS IN A BUCKEYE LOCATION, APRIL 24 TO JUNE 2, 1931

	Caucasian x Italian hybrids	Carniolan x Italian hybrids	Difference in favor of Carniolan cross
Number of colonies	10	10	0
Total number of frames of bees:			
At beginning of period (about)	117	117	Slight
At end of period	48½	66½	18
Number of colonies with eggs at beginning of period	10	10	0
Number of colonies temporarily without eggs during period	10	0	10
Number of colonies with eggs at end of period	8	10	2
Number of colonies with unsealed hatched brood:			
At beginning of period	10	10	0
At end of period	1	10	9
Total number of frames with sealed brood at end of period	8	32	24
Number of colonies with sealed brood:			
At beginning of period	10	10	0
At end of period	4	10	6
Total weight of colonies, in pounds:			
At beginning of period	710½	755	44½
At end of period	1,151½	1,216	64½
Total gain of colonies, in pounds	441	461	20

went through the buckeye flow much better than the Caucasian x Italian cross. After a short exposure to the buckeye, a striking difference in oviposition was noted: all the queens of the Caucasian x Italian cross stopped laying during a certain period; while those in Carniolan x Italian colonies continued to oviposit throughout the flow. Some of the differences are shown in Table 1.

After the buckeye flow was over, the lots of colonies were divided into three similarly treated groups. One group, after separation into two units, was moved to mountain locations (3,200 and 7,600 feet elevation); another was taken to a lowland valley floor; and the third remained in the original foothill location. Nectar sources were present in the moun-

[2]Two general types of Caucasian bees are sold commercially, gray and yellow. The stock employed in this study is of the gray type. Even this stock was rather variable in body color and somewhat variable in morphological characters. We also assume that there was some variation in physiological characteristics, because of the promiscuous matings and out crosses that cannot be controlled.

tain and foothill areas, but practically nothing was available in the valley. The valley yard, with only buckeye stores, fared very poorly; part of the colonies died out, despite ample stores, during the period of observation, and most of the remainder were weakened to a few bees. All the high-mountain colonies concerned with this phase of the work were destroyed by bears. Excluding these destroyed colonies, Table 2 gives a summary of the results between the Caucasian x Italian and Carniolan x Italian groups during the recovery period (June 2 to September 24) following their exposure in the buckeye area.

TABLE 2. COMPARATIVE DATA ON CERTAIN COLONIES UNDER OBSERVATION FOR RECOVERY, JUNE 2 TO SEPTEMBER 24, 1931

	Caucasian x Italian hybrids	Carniolan x Italian hybrids
Number of colonies concerned	7	7
Number of colonies that died out	3	1
Total number of frames of bees:		
At beginning of period	32	46
At end of period	24	55
Average weight of colonies:		
At beginning of period[1]	96	97
At end of period (living colonies only)[2]	82½	84½

[1]Both groups were treated similarly as to extraction of buckeye honey.

[2]The check colonies of nonbuckeye bees made an average gain of 68 pounds up to the end of July. They also made a good crop of honey after that time, but the weights are not available.

CONCLUSIONS. The results of comparison of the resistance to buckeye poisoning between the two sets of hybrids discussed in this paper are rather inconclusive. The Carniolan x Italian cross colonies were ahead of the Caucasian x Italians, as far as bees and brood were concerned, both at the end of the 1931 buckeye flow and at the end of the season. In the production of buckeye honey the two lots were nearly equal. Neither group made a perfect recovery.

THE CHANGING FLORA OF THE SOUTHWEST

By H. B. PARKS, *Texas Agricultural Experiment Station*[1]

ABSTRACT

The statement is made that for a proper explanation of the floral divisions of the Southwest an enumeration of the geological deposits must be given as the floral areas correspond more definitely to geological deposits than soil areas. An outline is given of the floral areas and distinctive plants. This gives the ideal picture of the Southwest before it was broken up for agricultural purposes. The present condition brought about by the inroads of agriculture and of overgrazing are reviewed. The conclusion is drawn that the native honey flora has almost disappeared. It is then

[1]Technical Contribution No. 184, Texas Agr. Exp. Station.

shown that in certain sections sweet clover, alfalfa and cotton have replaced the original honey flora. It is predicted that in much of the Southwest country much of the land now under cultivation or in overstocked ranges will return to pasture land but under the supervision of farmers who will recognize the fact that pastures require attention. This will mean the return of mesquite and other well known honey bearing shrubs and trees. Strains of sweet clover will develop which will maintain themselves throughout this district. The native horsemints which are aggressive will occupy the land now depleted by the plow and over-grazing. It is predicted that this combination will bring the Southwest back as a heavily producing honey area and that the honey produced will be sufficiently light in color to go into competition of the honey from the North.

For a proper understanding of what is to be said, it is necessary to outline the floral districts of Texas and to some extent the adjacent parts of New Mexico and Old Mexico. Texas was built around a group of islands which once occupied the central part of the state in what is now Mason and Llano counties. By the new measure of the age of rocks by radio activity, the granite of Central Texas belongs with the Ozarks and the other very primitive lands of the North American Continent. (1.) Around this nucleus the Pennsylvanian forms quite a deposit, then the Lower Cretaceous which is best known by the great shore line which crosses the state from Southwest to Northeast and is commonly called the Edwards Escarpment. West of this land mass, the Rocky Mountain Uplift, produced what is known as the high plains or the cap rock country and in West Texas the various mountain groups that are the southeast elongation of the Rocky Mountain system. The outwash from the Cretaceous shore line deposited the great black land belt of Texas. East of this comes the clay and sand deposits, most probably from rivers emptying into what was to become the Gulf of Mexico. This material came very largely from the highlands in what is now Oklahoma, Kansas and the Panhandle of Texas. East of this clay sand deposit comes the broad Gulf Coast Prairie which in very recent geological times has risen above the level of the Gulf. Upon this raw base, changes of climate and inroads of living organisms have made changes that gave us the Texas of yesterday. The most notable change was some shifting of wind and weather that made a dividing line between the humid and semiarid districts. This line roughly runs from Corpus Christi to San Antonio and then slightly east of north along the escarpment to the northern border. (2.) This is one of the most marked biogeographic divisions in the entire state and can be found on every map which shows the distribution of climatic conditions or of habitat of organisms. The plant divisions of the state correspond more nearly with the geological deposits than with the soil areas. (3.)

The honey flora as spoken of in this paper consists of those plants which furnish the common hive bee with nectar. In a study of the distribution of such plants within the state it was found that it was quite easy to divide the state into twelve very definite areas, each one of which has its distinctive flora. In most places the dividing lines between areas are very sharply marked, however, in others the transition zone is from twenty to thirty miles in width. There is another division of plant habitat which must be spoken of in order to explain certain apparent contradictions in what is said later in the paper. Throughout the state there are along water ways alluvial deposits varying in width from a few feet in the streams coming out of the escarpment to many miles in width along the lower courses of such rivers as the Colorado, the Brazos and the Trinity. These alluvial deposits maintain a population of plants composed of the members of all of the floral areas through which the waterway passes and in addition many species which belong to and are only found in river valley sections.

To briefly describe these areas, the first is that portion of the Northwestern part of Texas called the high plains. It starts at the Southeast corner of New Mexico and extends northeast to the northeast corner of Panhandle of Texas. It is bordered on the east by a very marked escarpment. The flora of this area is very largely the same as that found in Southeastern Colorado, Western Kansas and Western Nebraska. Up to a few years ago this was supposed to be a land where honeybees could not exist but with the coming of alfalfa and sweet clover attempts were made to raise bees and it was suddenly discovered that in certain localities bees would do well even where no introduced flora was present. The native honey plants being a low growing form of horsemint and a very extensive series of legumes and composites which are acceptable to the bees.

The second section is yet very largely without beekeepers. It consists of the north central plains of Texas lying between the cap rock country on the west and the black land area of the east. On the south it terminates with the granite hills. This section is composed largely of sandy loams. The few beekeepers residing in this district report that their honey flows come from legumes and composites. It has also been found that in certain sections cotton has given quite an addition to the native flora.

The black lands or cotton country of Texas is triangular in shape with the sharp point in Bexar county and the base of the triangle reaching from Grayson to Bowie County. The honey flow from this section comes entirely from introduced plants, mostly from that the greatest of

all crops in Texas, namely, cotton. It is a peculiar coincidence but prior to the monopolizing the blackland district by cotton, this locality was also the great honey producing section and it was in this section of the state that commercial honey production first reached its high development. The source of the honey of this early period was the blackland horsemint.

East of the blackland comes the timbered sections of Texas where beekeeping is in a most primitive form. It produces little commercial honey yet probably it contains as many colonies of bees as all the rest of the state put together. As one beekeeper expressed it, "It is so easy to raise bees that I do not try to use patented gums. I saw off a few more new logs and put them in place and the bees do the rest." Almost every farmer in Texas east of the Trinity river has from one to many colonies of bees and yet it is impossible to get any information as to the production per colony, so little attention is paid to honey production. Where there are commercial beekeepers their averages have been very large, but the quality of honey has not been as good as that of the central part of the state. The honey flora of this section is very largely hard wood shrubs, vines and trees. The youpons, eardrop, huckleberries, ratan and peppervine are commonly named as the best honey producers.

The Gulf Coast country is honey producing only where the alluvial lands cross the great grass prairie and in these locations are found some of the largest and best producing of the commercial beekeepers. Their honey flora is unique in that everything that is found in the land through which their river passes is present with them. In addition they have a set of hard wood honey plants which are found only in the alluvial soils of the Gulf Prairie and to give them an added amount cotton produces very well on these soils. The Gulf Prairie section ends about the Guadalupe river and here begins the Mesquite-Cactus-Chaparral of Clemmens. (4.) Its northern boundary has been given as a line from Corpus Christi to San Antonio, west through Uvalde to Del Rio. It is this section that has made Texas famous as a honey producing state. Honey produced by guajillo or guajillo-catsclaw comes entirely from this section and has taken more first prizes at great exhibits than any other honey in the world. The mesquite is well known as a producer. The other members of this chaparral association are all honey producers including even the much despised cactus. There is no part of this large section of the state commonly spoken of as Southwest Texas that does not have its commercial honey producers and which does not at times produce large quantities of honey. As with any semiarid district crops cannot be looked for only during optimum years, however, the optimum

for one set of plants is not that of others and a honey crop can be expected during the majority of years. It has been said and rightly too, that the probable cause of the prominence of beekeeping in this section is due to the fact that it is the home of beekeepers rather than this section is any better adapted to beekeeping than other sections. There is truth in this statement but just how much would be hard to ascertain.

At the South end of the chaparral section lies the lower Rio Grande Valley, small in extent and as a honey producing section not equal to many other parts of the state but for queen and pound package work it probably offers a greater inducement than any other portion. Here flowers bloom throughout the winter in quantities sufficient that queen rearing can be carried on at all times and package bees can be produced in large quantities sufficiently early to supply any demand and that amount of bees can be produced almost any time during the year. The peculiar conditions which exist cause abundant brood rearing throughout the entire year.

Texas west of the chaparral section to the Pecos river contains quite a large number of beekeepers but the conditions and the honey plants are vastly different from the chaparral. It is here that legume shrubs and white brush give the greatest amount of yield. Late summer composites furnish the bees their food for the winter and while bee locations are rare where they are found the production is high.

The Trans-Pecos part of Texas is mountainous and beekeepers are restricted to certain canyon and mountain valleys where springs allow the growth of large areas of various shrubs. Some of the highest yields per colony recorded in this state come from this section. The honey comes very largely from legumes. Quite an amount also comes from the century plants.

Along the upper Pecos River and near El Paso there exists two irrigated sections where bees are kept in large quantities and good crops of honey are made. Before irrigation and the introduction of alfalfa and sweet clover the honeybee was unknown in this section. Throughout the chaparral, the blackland, and the remainder of East Texas horsemint is an ever present honey producing plant. It is not always the same species but the genus is highly honey producing. It occurs in heavy stands and seldom misses a year. This ever present plant adds much to the volume of the honey produced in all sections of the state. A pure honey from horsemint is not of the best quality but in combination with the honeys of other plants makes a very pleasing combination.

The above is an idealized picture of the honey flora of Texas before the enormous stride which agriculture has made in Texas during the past

thirty years. At the present time the bulk of the native honey flora of this state has disappeared before the plow and the cow, however, the goat has largely assisted the great bovine army. With the breaking up of the great ranches came the agriculturists, most of them new comers to Texas and believing that all the soil needed was clearing and breaking up to produce the kinds of crops the farmers had become accustomed to farther east and north. In this they were mistaken. Hundreds of acres were cleared of brush and grass in the attempt to make cultivated fields out of pasture land. Failure came and these lands have now become abandoned farms on which Nature is trying her best to rebuild a protective flora. There is hardly a section of the state of Texas in which this condition is not true. In addition to this breaking of the soils where they never should have been molested, came another set of men who were not content with raising cattle in numbers that could be maintained on a certain piece of land but so increased this number that not only was the grass killed out by over grazing but many of the shrubs and small trees went the way of the grass. Following the over grazing came a flora of rough composites which took advantage of the barren ground and now have spread to such an extent that grazing is next to impossible. On many of the soils which were too steep and covered with rock for cattle grazing or agriculture, the herdsman with his sheep and goats appeared. Not content with the number that could be maintained, they increased the number until not only did all the grass and small herbs disappear but the bushes were so trimmed that they died. Since the World's War there has been an extremely rapid development of all lines of agricultural endeavor throughout the south and southwest Texas and as could be predicted, hundreds and thousands of acres of what ten years ago was good bee country today is barren soil which on an optimum year make up to the farmer for the work he puts in upon his crop but as a rule will not produce more than the barest of a living. Likewise much of the best honey producing section, that is, guajillo-catsclaw country, has been grubbed out to make way for the production of winter truck crops or has been so pastured with sheep and goats that these plants have been killed. Farther east in the state a great deal of the alluvial honey producing sections have been cut off and grubbed out to be turned into vegetable farms.

This increase of grazing and of agriculture has brought about a very deplorable condition on the part of the beekeeper. One beekeeper near the mouth of the Brazos river writes, "I do not know whether to continue in the bee business or not. My entire bee range has been cut off and turned into a cabbage patch. If I continue beekeeping it will be neces-

sary for me to find a new location and from experience, I must say I do not know where to find it." (5.) Throughout Texas this same complaint is heard everywhere. This trouble is not restricted to Texas. Dr. L. Haseman of Missouri, who has been intimately connected with beekeeping for thirty years writes, "I believe that the greatest problem before the beekeeper of Missouri, greater even than the disease problem, is that of providing a pasturage for bees." (6.) The State of Illinois passed through a development during the 80's and 90's that is similar to the condition now existing in Texas. The early history of beekeeping in Illinois tells of large yields of honey from white clover, from swamp plants and composites, then came the intense agricultural development of the state and by the middle 90's beekeeping had reached a very low limit. White clover almost disappeared before the plow and intense grazing. Then, came the introduction of sweet clover, certain smart weeds and Spanish needles and from the middle 90's to the present time the honey production of Illinois has been on the increase.

From our experience in Texas it is hard to tell whether we have reached the low point of honey plants or not. We hope we have. By what has happened in other states, it is possible to make some predictions as to what will happen. Already the blackland section has solved her problem. Cotton, an introduced plant, is her main source of honey. Likewise, the alluvial sections of the state will always have cotton as their major honey plant. In the chaparral district there is no doubt but what the native horsemints will come in and take possession of every vacant piece of land. Farms that will be abandoned will slowly come back to the original brush flora. No doubt plants not now thought of as being honey producers will be introduced and will occupy considerable territory within this section. Sweet clover is an easily adaptable plant and is forcing itself westward and is receiving the attention of seed growers and of those interested in forage plants and apiculture. Already strains of this plant are maintaining themselves as far west as San Angelo and it is very probable that in time Southwest Texas will look upon sweet clover as a major honey plant. Sweet clover together with horsemint, which is now here, will take the place of the shrubs and trees which once produced the large crops of honey. The quality of the honey will not be as good but the amount produced will be far greater. In addition to this, it is quite probable that the mesquite tree will come into prominence as a pasture shade. It is well known that when a forest has not reached its climax and the trees receive a maximum amount of light that they produce fruit heavily but where the climax is reached and only the upper branches receive the sunlight little or no fruit is produced.

Fifty years ago when the chaparral section was the home of many herds of cattle and was burned through every fall, the mesquite trees bloomed every year and mesquite honey was not only an annual crop but the yield was great. Today wherever the mesquite forests still exist because of the removal of the large herds of cattle and the fact they are no longer fired in the winter has allowed these forests to reach a climax. As a result it is only the outside trees and isolated trees that bloom, the result being that a mesquite honey flow now occurs in about once in a dozen years and then very locally. When the farmer learns that his pasture land should receive some attention and that if he wishes to maintain cattle, he must see that he has a limited amount of shade and that objectionable plants such as cactus and thorny shrubs are removed from the pasture then again there will be mesquite flows of ample dimension.

At the present time there are no plants under trial that are giving any promise for general sowing by the beekeeper or farmer with the object of honey production with the exceptions of horsemint and sweet clover. The future of beekeeping rests upon the extent to which secondary honey plants will take the place of the flora which is now largely extinct. From my observations I am led to believe that within ten years sweet clover and horsemint will have become so dispersed that the loss of the guajillo, catsclaw, mesquite and some others of the former prominent honeys of Texas will not be noticed and that the honey produced will be lighter in color and will be able to compete with the light colored honeys from the North which are now the strongest competitors of Texas honey.

Literature Cited

1. Forbes, Wm. T. M. Science, 74: No. 1916. p. 294.
2. Carter, W. T. The Soils of Texas. Texas Agriculture Station Bulletin No. 431, p. 15.
3. Cuyler, R. H.[1] Bulletin of the American Association of Petroleum Geologists, Vol. 15, No. 1.
4. Weaver, J. E., and Clemments, F. E. Plant Ecology, 1929.
5. Yancey, J. D., Bay City, Texas. A letter to the author, 1931.
6. Haseman, L. University of Missouri. A letter to the author, 1931.

[1]Vegetation as an Indicator of Geologic Formations.

SOME COMPARATIVE DATA ON MOISTURE IN TOP AND BOTTOM LAYERS OF HONEY AFTER A YEAR OF STORAGE, AS INDICATED BY THE VACUUM DRYING OVEN AND THE REFRACTOMETER

By G. E. Marvin and H. F. Wilson

Abstract

In taking samples of honey for moisture determination, the samples must be thoroughly mixed for during the process of crystallization there is shown to be a distinct variation between the amount of moisture in the top and bottom layers and the moisture content of the top layer is always greater than the bottom layer.

During the course of our work on fermentation of honey an occasion arose where it became necessary to know the moisture content of the top and bottom layers of 36 samples of honey, 12 samples having been stored in each of 3 temperature chambers held at 40, 60, and 80°F. respectively for a year. The moisture content was determined by two methods (1) Vacuum drying oven on quartz sand (2) Abbé Refractometer. Aside from the facts in question on fermentation, other interesting sidelights developed of which we shall present a few.

Method. The samples of honey that were used in this study were taken from the beginning of the honey flow June 26 to October 17, 1929. In taking the samples, the extractor and honey tank were cleaned with boiling water and then thoroughly dried. The honey was strained through 3 thicknesses of cheesecloth, just as it ran from the extractor and bottled immediately in sterilized bottles, which were sealed upon filling, labelled and put in the dark constant temperature chambers.

Sample	Date of Extraction	Condition of capping
1	June 26	Entirely uncapped
2	July 3	About 1/6 of comb surface capped over
3	July 10	About 1/4 of comb surface capped over
4	July 17	About 3/5 of comb surface capped over
5	July 24	About 3/4 of comb surface capped over
6	July 31	Few uncapped cells along bottom
7	August 7	Entirely capped
8	August 7	Entirely uncapped
9	August 14	Entirely uncapped
10	August 14	Completely capped
11	October 10*	Completely capped
12	October 17*	Completely capped

*Removed from hive on September 15. Stored in warm dry room until period of extraction.

The honeys were carefully removed from their storage chambers so as not to mix the two layers in uncrystallized samples. The top 1/4 of the honey in each bottle was spooned off into a dry wide mouthed bottle and corked: the middle layer was then removed leaving the bottom 1/4 in

which we were interested. The top and bottom samples were then melted up in a water bath at 50°C. and the liquid honey used for moisture determinations.

The official method recommended by the Association of Agricultural Chemists for determining this is a long slow process requiring special apparatus and technique. One is required to use pure quartz sand which will pass a 40 mesh but not a 60 mesh screen, then digest the sand in HCl and wash free from acid, dry and ignite. Twenty-five to thirty grams together with a short glass stirring rod are placed in a flat bottomed aluminum drying dish of 60 mm. diameter. This dish with contents is then dried in an oven, cooled in a desiccator and weighed. A quantity of honey sufficient to yield approximately 1 gram of solids is poured on the weighed sand and reweighed to the 4th decimal place to get the exact amount of honey. One cubic centimeter of distilled water is added to help incorporate the honey with the sand. Samples are run in duplicate and then put in the vacuum oven at 70°C under a pressure not to exceed 100 mm. of mercury for 15 to 17 hours. After drying the samples for this time, the pump is stopped and the oven brought to atmospheric pressure with dry air. The dishes are cooled in a desiccator and weighed, then put back in the oven for a further drying period of two hours after which they are removed again, weighed and if the change in weight does not exceed 2 mg. the loss in weight from the original is reported as the per cent of moisture.

The apparatus required by this method of obtaining the moisture content of honey is (1) a low speed motor and vacuum pump which is able to run 17 or 18 hours at a stretch, (2) an electric vacuum oven (3) a sensitive balance weighing to the 4th decimal place (4) aluminum flat bottom drying dishes and (5) desiccator, together with various other minor equipment.

ABBÉ REFRACTOMETER. Diffused daylight was used as the source of light for these readings. Water was circulated through the prisms, keeping them at 20°C. for if other temperatures are used, corrections must be made. The double prisms were opened and a few drops of honey put on them by means of a glass stirring rod.

The method of measurement is based upon the observation of the position of the border line of total reflection in relation to the faces of the prism of flint glass. This border line is brought into the field of the telescope by rotating the double prism until the field of vision is divided into a light and a dark portion. The line dividing these portions is the border line and as a rule will not be a sharp line but a band of color, but by rotating the compensator, a sharp, colorless line is obtained. The

TABLE 1. MOISTURE IN TOP AND BOTTOM LAYERS OF HONEY STORED IN 40° F. CHAMBER AS DETERMINED BY VACUUM OVEN AND REFRACTOMETER

Sample	Top			Bottom			Difference Top and bottom		Type of granulation
	Oven	Refractometer	Difference	Oven	Refractometer	Difference	Oven	Refractometer	
1	19.71	21.8	2.09	15.94	18.2	2.26	3.77	3.6	Coarsely granulated; a little liquid on surface
2	17.20	20.0	2.80	16.86	19.4	2.54	.34	.6	Coarsely granulated; a little liquid on surface
3	17.50	20.0	2.50	16.93	19.2	2.27	.57	.8	Fine granulation; dry
4	18.51	21.0	2.49	17.44	20.0	2.56	1.07	1.0	Fine granulation and dry as in 3
5	16.46	19.1	2.64	16.06	18.6	2.54	.40	.5	Fine granulation and dry as in 3
6	17.15	19.3	2.15	16.42	18.7	2.28	.73	.6	Fine granulation and dry as in 3
7	18.42	20.8	2.38	16.94	19.3	2.36	1.48	1.5	
8	20.59	22.8	2.21	18.87	21.2	2.33	1.72	1.6	Like 1 and 2
9	22.45	24.0	1.55	20.55	22.5	1.95	1.9	1.5	Like 1 and 2
10	18.94	21.2	2.26	17.67	20.0	2.33	1.27	1.2	Fine granulation and dry as in 3
11	16.05	18.3	2.25	15.86	18.3	2.44	.19	0	Very fine granulation creamy appearance
12	16.55	18.9	2.35	16.18	18.6	2.42	.37	.3	Very fine granulation creamy appearance

border line should be adjusted so that it falls on the point of intersection of the cross hairs, after which the refractive index of the honey should be read directly on the scale of the sector. By the use of Schönrocks table one is able to obtain the per cent of water found in a sugar solution with that refractive index—no table having been worked out for honey.

This method is extremely easy and the only apparatus required is an Abbé refractometer with a supply of water kept at a constant temperature.

It is not our purpose to discuss the relative merits of the two methods of determining the moisture in honey but to present our results and to encourage further work in this connection with a method which seems to have promise.

Table 1 shows the moisture reading of the top and bottom layers of honey stored in the 40°F. chamber by the two methods. Differences in moisture between the two layers ranged from .19 to 3.77 per cent for the honeys dried in the vaccum oven and 0 to 3.6 per cent on the refractometer. In all cases the refractometer moisture readings were above the moisture readings obtained by the vacuum drying oven method. The differences in the case of the readings of the top layer by the two methods ranged from 1.55 to 2.80 per cent and for the bottom layer readings from 1.95 to 2.56 per cent.

Table 2 shows the moisture reading of the top and bottom layers of honey stored in the 60° chamber by the same two methods. Differences in moisture between the two layers ranged from .65 to 3.15 per cent for the honeys dried in the vacuum oven and .7 to 3.6 per cent on the refractometer. As with the samples before, the refractometer moisture readings were above the moisture readings obtained by the vacuum drying oven method. The differences in the case of the readings of the top layer by the two methods ranged from 1.70 to 2.62 per cent and for the bottom layer readings from 1.48 to 2.64 per cent.

Table 3 shows the moisture readings of the top and bottom layers of honey stored in the 80°F. chamber by the same two methods. The moisture in the two layers did not show the variation that the honey did when stored in the 40 and 60°F. chambers. Two samples, 11 and 12, showed a slightly greater moisture content by the oven drying method in the bottom layer than the top. The first sample which was entirely uncapped still showed a high variation of 3.73 per cent between the moisture of the two layers. Outside of these three samples by the oven method of drying, the moisture ranged from .49 to 1.3 per cent and .2 to 1.7 on the refractometer. As with the samples before, the refractometer

TABLE 2. MOISTURE IN TOP AND BOTTOM LAYERS OF HONEY STORED IN 60° F. CHAMBER AS DETERMINED BY VACUUM OVEN AND REFRACTOMETER

Sample	Top			Bottom			Difference Top and bottom		Type of granulation
	Oven	Refractometer	Difference	Oven	Refractometer	Difference	Oven	Refractometer	
1	21.38	24.0	2.62	19.0	21.6	2.60	2.38	2.4	Upper ¼ liquid. Lower coarsely granulated
2	19.50	21.2	1.70	17.02	19.3	2.28	2.48	1.9	Coarsely granulated; liquid between crystals ½ inch liquid on top
3	20.16	21.9	1.74	16.67	18.9	2.23	3.39	3.0	Smaller crystals than above—rest same
4	19.74	21.6	1.86	17.43	19.7	2.27	2.31	1.9	Like 2
5	17.73	20.0	2.27	16.42	18.9	2.48	1.32	1.1	Semisolid—coarse crystals
6	18.32	20.2	1.88	16.54	19.0	2.46	1.78	1.2	Semisolid—coarse crystals
7	17.64	20.0	2.36	16.99	19.3	2.31	.65	.7	Very fine granulation
8	22.09	24.0	1.91	18.92	21.4	2.48	3.17	2.6	Medium coarse crystals; ⅓ liquid on top
9	24.77	26.8	2.03	21.72	23.2	1.48	3.05	3.6	½ coarse crystals; ½ liquid
10	21.8	23.8	2.00	18.65	20.8	2.15	3.15	3.0	Very fine granulation complete
11	16.72	19.2	2.48	15.66	18.3	2.64	1.06	.9	Same as 10
12	17.68	19.9	2.22	16.18	18.5	2.32	1.50	1.4	Same as 10

TABLE 3. MOISTURE IN TOP AND BOTTOM LAYERS OF HONEY STORED IN 80° F. CHAMBER AS DETERMINED BY VACUUM OVEN AND REFRACTOMETER

Sample	Top			Bottom			Difference Top and bottom		Type of granulation
	Oven	Refractometer	Difference	Oven	Refractometer	Difference	Oven	Refractometer	
1	20.84	23.0	2.16	17.11	21.3	4.19	3.73	1.7	Upper ¼ liquid. Lower coarsely granulated
2	18.01	20.1	2.09	16.73	19.1	2.37	1.28	1.0	Upper ⅛ liquid; rest coarsely granulated
3	17.56	20.0	2.44	16.33	18.6	2.27	1.23	1.4	Crystals fine; ¼ inch liquid at top
4	18.62	20.5	1.88	17.73	20.3	2.57	.89	.2	Coarse crystals from top to bottom; liquid in between
5	16.88	18.7	1.82	16.30	18.5	2.20	.58	.2	Same as 4
6	16.84	19.0	2.16	16.35	18.5	2.15	.49	.5	Completely granulated; very fine
7	16.47	19.1	2.63	15.73	18.8	3.07	.74	.3	Same as 6
8	20.98	22.8	1.82	19.68	21.5	1.82	1.3	1.3	Coarse crystals ⅛ inch liquid on surface
9	22.37	24.4	2.03	21.72	23.8	2.08	.65	.6	¼ medium coarse crystals; rest liquid
10	18.92	21.2	2.28	17.76	20.0	2.24	1.16	1.2	Coarse granulation; ⅛ inch liquid on surface
11	15.63	18.1	2.47	15.92	18.2	2.28	—.29	—.1	Medium coarse granulation complete
12	16.06	18.3	2.24	16.07	18.3	2.23	—.01	0	Same as 11

moisture readings were above the moisture readings obtained by the vacuum drying oven method. The differences in the case of the readings of the top layer by the two methods ranged from 1.82 to 2.63 and for the bottom layer readings from 1.82 to 4.19.

Discussion. From the constant difference between the moisture readings obtained by the two methods, it appears that some factor can be worked out, or a table constructed on which one can read the correct moisture in honey by the refractometer. In this way a few minutes will be consumed where over 24 hours are required to obtain the moisture by the vacuum drying oven method.

Our work has shown us that in taking a sample of honey for moisture determination it is very important that the two layers be thoroughly mixed. Also it is not advisable to take a sample from the top of a can to show to a prospective buyer, for honey thoroughly mixed will have a better body. Just recently a discussion came up when it was proposed to take a sample from the top of 60 lb. cans to find out if the honeys came up to the standard weight per gallon. A method of sampling such as this would not be fair as shown by the tables, for in granulating there is bound to be a separation with the lighter honeys rising to the top.

Bibliography

1. 1930. Official and Tentative Methods of Analysis of the Asso., of Official Agr., Chemists.
2. 1931. The Effect of Temperature on Honey in Storage. H. F. Wilson and G. E. Marvin. Journ. Econ. Ent. 24, pp. 589–593.

HONEY FLOW FROM GOLDENROD IN ITS RELATION TO TEMPERATURE[1] AT DONALDSONVILLE, LA.

By E. Oertel, *Assistant Apiculturist, Division of Bee Culture Investigations, Bureau of Entomology, U. S. Department of Agriculture*

Abstract

Temperature factors have been correlated with the daily gross gains in weight of one colony of bees, at Donaldsonville. The study covers only the goldenrod honey flow for 1930.

The gross daily gains in weight of a colony of bees located near Donaldsonville, La., have been studied in relation to certain available

[1]A contribution from the Southern States Bee Culture Field Laboratory, Baton Rouge, La., maintained by the Division of Bee Culture Investigations, Bureau of Entomology, U. S. Department of Agriculture, in cooperation with Louisiana State University.

temperature data.[2] Temperature variation, average temperature, maximum temperature, and minimum temperature were obtained from Weather Bureau reports. The "average temperature" was obtained by averaging the recorded maximum and minimum temperatures. Only gross gains in weight of one pound or over per day are included. At Donaldsonville gains began, after losses in September, on October 3, 1930, and continued, except for three interruptions, until October 28. Most of the days during October are recorded as "fair." It is believed that practically, if not entirely, all the gains in weight are due to the nectar gathered from goldenrod (*Solidago* sp.), which grows abundantly within flight range of the scale colony.

TABLE 1. CORRELATION COEFFICIENTS, STANDARD ERRORS OF ESTIMATE, AND REGRESSION EQUATIONS BETWEEN GROSS DAILY GAINS AND WEATHER FACTORS

Independent variable	Correlation coefficient	Standard error of estimate	Regression equation
		Pounds	
Variation in temperature (A).....	+.364	2.515	x=1.358+.161A
Average temperature (B).....	—.035	2.698	x=5.941—.016B
Maximum temperature (C).....	+.193	2.649	x=5.209+.123C
Minimum temperature (D).....	—.157	2.666	x=8.028—.055D

x=dependent variable (gross gain).

Table 1 gives the coefficients of correlation between gross daily gains and weather factors and the regression equations. None of the correlation coefficients show a significant relationship between gains in weight and temperature, although the value of Gn. Var. (correlation coefficient between gain and temperature variation) might be considered to indicate that there tends to be a relationship between temperature variation and gains in weight. The correlations between gross gains in weight and average temperature, maximum temperature, and minimum temperature are too small to be significant. Of course, temperature variation depends upon maximum and minimum temperatures. Although the number of cases (number of days of gain) is rather small, 22 in all, that does not furnish a satisfactory explanation as to why the weather factors show apparently little relation to gains in weight in the fall period. If weather conditions during the honey flow are such that large daily gains occur, no doubt a high correlation between weather and colony gain in weight would be indicated. Information concerning the weather and the honey flow from goldenrod in other sections of the country would be of considerable interest and of value

[2]These records were obtained through the kind assistance of E. C. Bessonet, at Donaldsonville, La.

for comparison. The number of field bees that are present in the hive and able to gather the nectar is important, perhaps more so than certain weather factors. Under equal conditions a colony with a large force of field bees will show a higher daily gain than a weak colony. It is, of course, difficult to compare colony strength. The condition and strength of the colony of bees used in this study are unknown.

TABLE 2. RECORD OF GROSS GAINS AND WEATHER DATA AT DONALDSONVILLE, LA. IN OCTOBER, 1930

Date	Gross gains *Pounds*	Temperature variation	Average temperature °F.	Maximum temperature °F.	Minimum temperature °F.
3	1	24	70	82	58
4	1	19	70	80	61
5	2	14	73	80	66
6	1	16	78	86	70
8	4	10	75	80	70
9	3	19	76	86	67
10	6	18	81	90	72
11	4	12	76	82	70
12	8	18	75	84	66
13	5	20	72	82	62
14	8	25	71	84	59
15	8	24	70	82	58
16	10	26	73	86	60
18	2	20	64	74	54
19	4	24	62	74	50
20	8	21	67	78	57
21	6	26	67	80	54
22	6	26	65	78	52
23	4	24	68	80	56
25	4	27	60	74	47
26	7	32	62	78	46
27	3	26	69	82	56
Total	105	471	1,544	1,782	1,311
Average	4.7	21.3	70.2	81.0	59.6
Standard deviation	2.6	5.9	5.7	4.1	7.6

The regression equations given in Table 1 indicate trends of association between gains in weight and temperature, but owing to the relatively large size of the standard error of estimate, these regression equations are of little value. Apparently maximum temperatures of about 90°F. would result in a greater daily gain, provided that the minimum temperature were 70°F. or less. The mean maximum temperature for October at Donaldsonville is about 80°F., consequently, the honey flow from goldenrod probably is not so large as it might be were the daytime temperatures higher.

Table 2 gives a record of the daily gross gains in weight of 1 pound and over, together with the temperature data, for October. Probably the period from October 10 to 16, inclusive, represents the peak of the

goldenrod honey flow, for the gains tend to become smaller during the latter part of the month. A net gain of about 50 pounds resulted from the gross gain of 105 pounds. Such a gain probably compares favorably with the gains from a goldenrod honey flow in other parts of the country. Disregarding possible loss of field bees, a comparison of the weights 105 pounds and 50 pounds shows that the net gain during the goldenrod honey flow is about half of the gross gains. It is probable that, even if the weather had not changed, the honey flow would not

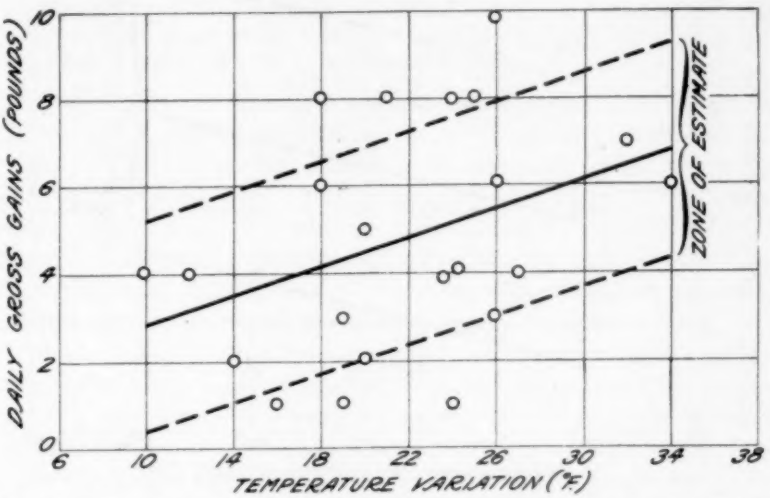

FIG. 30.—Dot chart showing gross gains in weight and temperature variation with line of regression.

have lasted many days longer. Both the maximum and the minimum temperatures, especially the latter, show a tendency to decrease. Of course, the average temperature decreases with the maximum and minimum, but temperature variation is larger during the latter phase of the honey flow. It is impossible to ascertain the exact effect of the rainfall on October 7, 17, and 24. The small gain of October 18 is noticeable and may be due partly to the rather low maximum temperature (74°F. on the 18th) and partly to the influence of rain.

The accompanying dot charts show more clearly the regression lines for gross gains and temperature variation (Fig. 30) and for gross gains and maximum temperature (Fig. 31). A conspicuous grouping of the gains occurs between the temperature variation of from 18° to 26°F., inclusive. Fifteen of the 22 days, or 68.2 per cent are so included. Eighty-five pounds of the total gross gain of 105 pounds, or 80.9 per

cent, are gathered in 68.2 per cent of the total number of days during which gains are recorded. In Figure 2 the gross gains do not show much spread, all but one day's gain occurring between the maximum temperatures of 74° and 86°F.

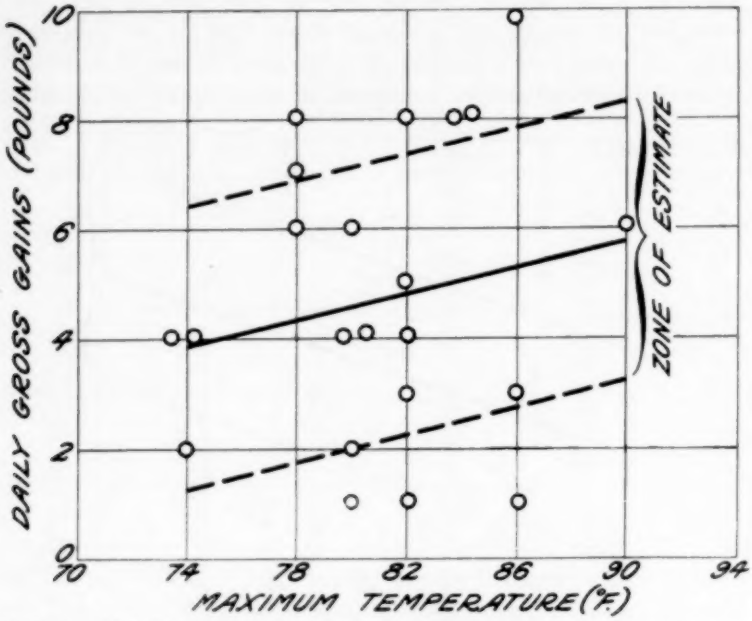

FIG. 31.—Dot chart showing gross gains in weight and maximum temperature with line of regression.

SUMMARY. The honey flow from goldenrod at Donaldsonville, La., lasted from October 3 to 27, 1930.

No significant correlations exist between the available temperature data and daily gross gains. The correlation coefficient between gross daily gain and variation in temperature indicates that there is a tendency for the daily gain to increase as the temperature variation increases. The correlations between average temperature, maximum temperature, and daily gross gains are so small that they cannot be considered to show any relationship between those factors and colony gain.

THE RELATION OF TEMPERATURE TO THE DETERIORATION OF HONEY IN STORAGE—A PROGRESS REPORT

By H. F. WILSON and G. E. MARVIN

ABSTRACT

Continued observations on the relation of temperature to the deterioration of honey in storage show that severe losses due to deterioration of honey in storage can be prevented. Somewhere below 55°F. honey can be safely stored for indefinite periods. At a range of temperatures somewhere between 55°F. and 70°F. optimum conditions are provided at which the majority of honies may be expected to ferment.

At a temperature of 80°F. or slightly below, fermentation develops slowly in unripe, and probably not at all, in well ripened honies.

A preliminary report on this project, as being conducted at the Wisconsin Agricultural Experiment Station was presented before this group at last year's meeting, and published on pages 589 to 597 of the June, 1931, issue of "The Journal of Economic Entomology." The present paper is for the purpose of adding a few additional notes to the previous paper, and to present additional observations on the 1930 samples to point out what we believe to be some significant facts in the relation of temperature to the deterioration of honey in storage.

The true story of what happens cannot be presented until additional observations have been obtained. However, we believe that when the picture is complete, a real contribution will have been made in the saving of serious monetary losses to both beekeepers and honey dealers in the prevention of the deterioration of honey while in storage. It is necessary to conduct further experiments with temperatures ranging between 40, 60 and 80°F. to determine the high and low point at which honey may be stored and also to determine the most economical storage condition. The data secured to date would indicate that honey may be preserved indefinitely, both as to flavor and color, at a storage temperature somewhere within the range of 40 to 55°F. This data also shows that 80°F. is a border-line temperature, at which point honey may be preserved for a year or more, with only slight changes in color and flavor, and with a minimum danger of fermentation of so-called "ripened" honey.

Upon the basis of these observations, it is entirely possible to find a temperature somewhat below 80°F., that will make it possible to store honey over a considerable period of time, without any serious change in color or flavor, and with practically no danger of fermentation.

Another fact to be gained from these observations is that there is a line of temperatures between 55 and perhaps 65 or 70°F. at which it is extremely dangerous to store even so-called "ripe" honey.

No additional changes of the 1929 samples, stored in the 40° and 60° chambers have been observed, but significant changes have occurred in some of the samples in the 80° chamber. Of the series of 12 samples reported on at the last meeting, only one had shown definite signs of fermentation. In October, 1931, after two years in storage, samples No. 1, 2, 8 and 9 showed definite fermentation. A study of the description of these samples shows that they were all taken from unsealed honey, and may therefore be classified as unripe honies.

TABLE 1. DATES OF EXTRACTING AND CONDITION OF COMBS

Sample No.	Date extracted	Condition of capping
1	July 9	All uncapped
2	July 16	Only a few cells capped
3	July 23	Approximately one-fourth of cells capped
4	July 30	Approximately two-thirds of cells capped
5	August 6	Approximately three-fourths of cells capped
6	August 15	All cells capped
7	August 22	All cells capped
8	August 27	All cells capped

None of the samples taken from fully capped combs have so far shown any indication of fermentation, but there is sufficient loss in flavor and darkening of color to make it undesirable to maintain honies in storage at that temperature for more than a year's time.

SOURCE OF SAMPLES. The samples of honey used in this study were taken from samples extracted in the University Apiary at nearly weekly intervals from July 9 to August 27, 1930. In taking the samples, the extractor and honey tank were each time cleansed with boiling water and thoroughly dried. The honey was strained through three sheets of cheese-cloth, as it ran from the extractor and immediately put in sterilized jars. The bottles were then labelled and a series of a half dozen or more jars put in each of the temperature chambers.

An examination of the data presented in Table 2 shows that when the samples were examined on October 6, 1931, the samples in the 40° chamber had not changed as to color, and the flavor was excellent. No signs of fermentation had developed. The samples in the 80° chamber had not changed appreciably in flavor, but were slightly darker in color than when first put into the chamber. The samples in the 60° chamber had not changed in color, but samples 1 to 5 and 8 were distinctly fermented. It is easy to understand why samples 1 to 5 would ferment, because they may be considered as unripe honies, and may be considered subject to fermentation. But it is hard to explain why sample No. 8 became fermented, while samples 6 and 7 showed no signs of yeast development. We must wait for further time to elapse before we can determine whether or not any of the samples will ferment in the 80°

chamber, but previous observations show that fermentation may occur at this temperature, and we may expect the less ripe samples to develop fermentation later. Apparently, at this temperature, the yeasts occurring in these samples are not able to grow, or, at most, develop very slowly. It may be that the amount of inoculum present may have some effect, for it is well known that different amounts of inoculum present in the sample affect the development of fermentation.

TABLE 2. CONDITION OF SAMPLES DECEMBER 1, 1931

Sample No.	Fermented	Type of Granulation
80° Chamber		
1	no	All liquid but about one-eighth inch of crystals on bottom dirt specks settled to bottom and liquid part clear
2	no	Same as No. 1, but with about one-fourth inch deposit of crystals on bottom
3	no	All liquid except an uneven layer of fine crystals at bottom ranging from one-half inch to inch in thickness. Patches of crystals forming on sides of jar.
4	no	Semisolid throughout with creamy texture.
5	no	One-fourth inch solid at bottom; entire mass opaque because of minute crystals. Groups being formed on sides.
6	no	Layer of crystals three-quarters inch thick at bottom. Minute crystals all through the liquid and groups on the sides.
7	no	Nearly solid except three-fourths inch at top. Crystallization very fine.
8	no	One half of sample crystallized. Upper half liquid with fine crystals forming.
60° Chamber		
1	yes	All crystallized except one-half inch at top. Crystals loose and coarse.
2	yes	Solid with loose crystallization.
3	yes	Solid with loose crystallization.
4	yes	Solid with loose crystallization.
5	yes	Solid with loose crystallization.
6	no	Solid with closely grained crystals.
7	no	Solid with closely grained crystals.
8	yes	Solid with closely grained crystals.
40° Chamber		
1	no	Crystallized solid. Crystals flaky.
2	no	Crystallized solid. Crystals flaky.
3	no	Crystallized solid. Crystals flaky, but less so.
4	no	Crystallized solid. Crystals flaky, but less so.
5	no	Solid. Creamy texture.
6	no	Solid. Creamy texture.
7	no	Solid. Creamy texture.
8	no	Solid. Creamy texture.

However, in these samples, it must be considered that the inoculum is of equal intensity in each series of samples, since they were all taken from one large sample of the date indicated, and since all of the samples of the same date have fermented in the 60° chamber, it must be that the higher temperature alone is responsible for the lack of fermentation in the 80° chamber. The higher temperature may have produced some

physical or chemical changes which have inhibited yeast growth, but this is yet to be determined. In any event, we have results identical with those obtained from the 1929 samples, which provides the necessary proof to show that storage temperatures are of extreme importance for the preservation of honey in storage.

HAYDITE AS A SUBSTITUTE FOR WOOD IN THE CONSTRUCTION OF BEE HIVES[1]

By LEONARD HASEMAN

ABSTRACT

In search for a more satisfactory substance as a substitute for wood in the construction of bee hives, clay tiles, concrete and a form of concrete in which Haydite is used in place of sand and gravel have all been investigated. Durability, favorable thermal properties, and cost are important items to consider. Bees housed in hives made of Haydite suffered less from heat last summer than did those in wooden hives, and thus far this winter they seem to be comfortably housed.

Throughout the millions of years that the honeybee has probably been carrying on its usual business, the question of a safe and a comfortable abode has always been important. In nature the bee may select any suitable dry cavity in a tree, stump, cliff, or even a rock cavern. Protection from weather and enemies is most essential. Man, in his attempt to provide for the bee similar abodes, has at various times used sections of hollow logs, clay tiles, straw skeps, boxes, barrels, and various other receptacles. All things considered, wood has been used most but several other materials are satisfactory to the bee.

When the modern hive was devised, naturally wood was the most readily available substance and the easiest material to use in shaping the receptacle. That the modern hive revolutionized beekeeping goes without saying. However, this was primarily due to the fact that it facilitated the handling of bees and made possible the various practices so essential in modern beekeeping. The modern hive falls far short of an ideal abode for bees when durability, comfort, and protection from the elements and from enemies are considered. The native bee tree, the gum, and the skep provided far greater protection from the cold of winter and the burning heat of the summer and usually they furnish equally good protection from outside enemies. If the walls of our houses consisted merely of white pine boards seven-eighths of an inch thick, we would not consider that very good protection even though we have our furnaces and stoves to furnish the heat. Then too, unless they are well

[1]Contribution from Department of Entomology, Missouri Agricultural Experiment Station, Journal Series No. 336.

taken care of, hives are subject to weathering and warping, and to destruction by fire, decay, termites, ants and mice. In other words, wood as used in bee hives is not satisfactory, either as regards its durability or insulating properties.

The department of entomology of the University of Missouri has been interested for a number of years in investigating different materials as substitutes for wood and in experimenting with various sizes and shapes of hives. The ideal substance would be one that would resist fire and weathering, the attack of rots and gnawing animals, and at the same time possess favorable thermal properties. Clay, naturally, stands out as a substance worth consideration. It is readily available, easy to mold and handle, and has most of the desirable qualities. As in the formation of building tile it can be fed through dies so constructed as to provide for one or more dead air spaces in the walls of the finished product. One of the largest tile manufacturing companies in the United States became interested in the possibility of producing double or triple-walled tile hives with or without glazing. However, the one thing which they claimed that they could not control was the warping of the walls in the burning process. The material showed promise of being satisfactory and the handling of everything except the burning was relatively simple. Tile hives could be made at a very low price and with reasonable care they would last forever. We are still hopeful that the difficulty of warping may be overcome and that we may yet have an opportunity of testing out tile bee hives.

Being obliged to abandon hopes of using double-walled tile hives, for the time being at least, we turned our attention to the possibility of constructing hives of cement with reinforcement. Cement possesses some of the desirable properties but it also has some undesirable properties. Its insulating properties are not good, it is cold, and with changing temperature it "sweats" badly.

Recently there has come on the market a product known as Haydite. It is described as artificial or man-made volcanic pumace. Clay heated under pressure is suddenly released and cooled, producing a very light porous pumace-like product. This can be ground to any degree of fineness desired and used with cement in producing a light porous but strong concrete. One of the silo block manufacturers has become interested in making bee hives of this product. Last summer the company made a few of these hives for us to test out. They are heavier than wood hives naturally, but their weight is not particularly objectionable if looked upon as a permanent lifetime fixture in the bee yard. They can be molded with any thickness of wall desired and in any size

or shape of hive. The company is equipped to make hive bodies, supers, covers and bottoms but we have advised them to consider making only the bottoms, brood chambers and covers in case they prove a success. The beekeeper will find the lighter wooden supers easier to manipulate during the summer. Theoretically, they appear to be about what we have been wanting. They are proof against fire, decay, gnawing animals, and weather action, they have desirable thermal properties, and can be thoroughly waterproofed if that proves necessary. However, we are experimenting with them and until we are convinced that they are superior to our present wooden hives we cannot recommend them or encourage the company to enter upon their commercial production.

Early in July two colonies of bees were placed in these hives with walls approximately an inch in thickness. Recently, for wintering, a third colony was placed in one with walls approximately two inches thick. Last summer during the hottest weather the bees in wooden hives clustered outside in large masses and appeared to suffer greatly from the intense heat, while those in the experimental hives scarcely laid out at all. The bees did not show any dislike for the concrete and they stored a fair crop of surplus honey. Recently, when preparing the colonies for the winter, one hive was found to have a quantity of condensation on the under side of the cover. On this hive there was one extra unfilled super. In the second hive the cover was perfectly dry. In each case, however, a pad has been placed under the cover to take up any condensation which may tend to collect. Our experience with these new hives thus far leads us to expect that they are going to prove satisfactory, but we will know more about them by next summer.

Section of Extension

Wednesday Morning, December 30, 1931, New Orleans, Louisiana

The program was opened with a brief address by the Chairman, Dr. Leonard Haseman, Columbia, Missouri. The features of this meeting were the address by A. B. Graham, Principal Agriculturist of the United States Department of Agriculture, on the subject "How We Can Reach More People," and the Symposium on Orchard Spray Service.

The Committee on Nominations, appointed by the Chairman, consisted of P. D. Sanders, C. F. Stiles, and W. A. Price. The Committee recommended, and the Section elected, as Chairman for 1932, L. A. Stearns, Newark, Delaware, and as Secretary, M. P. Jones, Washington, D. C.

The Committee on Resolutions, consisting of J. J. Davis, C. O. Eddy, and Clay Lyle, presented resolutions that were unanimously adopted as follows:

Be it resolved that the Section of Extension of the American Association of Economic Entomologists express its thanks for the excellent facilities and conveniences offered for the sectional meeting, and that the Secretary be instructed to transmit to the General Secretary this expression of appreciation.

Be it further resolved that we extend to Mr. A. B. Graham our very deep appreciation for his worthwhile and interesting address, and that we express to the Secretary of Agriculture and the Director of Extension of the United States Department of Agriculture our thanks in permitting Mr. Graham to meet with us.

R. W. HARNED, *Ex-Secretary, Section of Extension*

LIST OF THOSE IN ATTENDANCE

Norman Allen, Louisiana State University, U. S. D. A. Research, Baton Rouge, La.
W. A. Adams, A. & M. College, Miss.
F. P. Amsler, Gulfport, Miss.
W. G. Arnstein, University of Arkansas, Fayetteville, Ark.
J. H. Bigger, Jacksonville, Ill.
C. L. Burkholder, Lafayette, La.
H. H. Carpenter, Houston, Miss.
E. L. Chambers, Madison, Wis.
O. M. Chance, Jackson, Miss.
S. C. Chandler, Carbondale, Ill.
K. L. Cockerham, Biloxi, Miss.
R. P. Colmer, Moss Point, Miss.
R. B. Deen, Tupelo, Miss.
N. L. Douglass, Grenada, Miss.
C. O. Eddy, Experiment Station, Lexington, Ky.
A. B. Graham, U. S. D. A., Washington, D. C.
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THE INSTRUCTION IN ENTOMOLOGY IN THE 4-H CLUB CAMPS OF MISSOURI

By GEORGE D. JONES, *Extension Specialist in Entomology*

ABSTRACT

Every club member was instructed to bring a cigar box, specially prepared in advance, to camp. Pins, labels, pencils, record sheets, killing jars and nets were furnished. The boys and girls were divided into two big groups to receive instruction while at camp. There were three one hour instruction periods each of the three days while in camp. The entomology work was divided into periods for field trips as well as for laboratory work. Each club member was to collect ten specimens of insects from a list of twenty-five of the most important insects likely to be found in any part of the state. They were required to mount them in cigar boxes and to fill in record sheets telling of the life cycle and life habits of each.

There were ten camps held in the state with a total attendance of 1,115 members. The work as a whole was received with enthusiasm and was considered successful.

Early in the year of 1931 the 4-H club agents of the Missouri College of Agriculture asked for assistance in preparing nature study work for their 4-H Club Camps. The study of entomology was decided upon. The outline of the study was perfected and each club member received the suggestions before leaving for camp.

ORGANIZATION. Every club member who attended camp was instructed to bring certain material to camp with him. Each brought cigar boxes or a similar box which was about 2″ x 2″ x 8″ with a lid. A corrugated strip of paste board was glued to the bottom of the box. This was done by the boy or girl at home. Ordinary stick pins were used for mounting purposes. Pins, labels, pencils and a laboratory manual with record sheets were supplied to each member at the camp.

There usually was time for three one hour periods of collection for each camp as well as for three one hour periods of laboratory work. By dividing the time it was possible for each club member to take part in the discussion groups held by the club agents as well as take part in the field trips and laboratory periods. This necessitated the dividing of the entire camp into two big groups for three one hour periods of instruction which began at 9:00 A. M. and lasted until noon. While Group one was in the discussion class with the club agents, Group two would go out for a field trip. This would be for the first hour. The second hour, Group two, which was out on the collecting trip would come in for their laboratory period and Group one which was in the discussion class the first period would go out for their field trip. The third hour Group two which was in the laboratory would go to the club agents for their discussion period and Group one which had completed their field

trip would come in for their laboratory period. This may be diagrammed as follows:

	9:00 A. M.	10:00 A. M.	11:00 A. M.
Group I	Discussion	Field Trip	Laboratory
Group II	Field Trip	Laboratory	Discussion

To further divide the group while out on the field trip, each group was divided into groups of five, each group being supplied with a killing jar and a net. The killing jar was used to carry the collected specimens to the laboratory where the group of five worked together in pinning the specimens in their boxes.

METHOD OF INSTRUCTION. In order to have some one to assist with the laboratory work and the field trips, the county agents and home demonstration agents were instructed to assist with the field trips as well as the laboratory work. After the first day, this system worked very smoothly and everybody was able to do his part well. Pictures and material were posted in the laboratory to assist in identification and in the life cycle studies of the insects collected. This was a great help to the county agents as well as the club members.

Each club member was required to collect ten specimens from a list of twenty-five which were chosen as being the most common and important insects likely to be found in any part of the state. Only a very few substitutions had to be made. The drouth cut down insect population in some sections of the state which caused a shortage of required material at a few camps. They had three one hour periods to collect the ten specimens. A few collected most all of them the first period but the greater percentage required all three one hour per day periods to secure their ten specimens. Most all did a very good job of mounting the insects in the cigar boxes. There were questions and blank spaces about each insect to be filled in on the record sheets. These consisted of questions about color, where collected, kind of life cycle, where it spends the winter and other features about its life habits. It was surprising how well some filled in their record sheets.

Prizes and honorable mention were made as a reward to those who did the best job of collecting, mounting and writing up their records. Much enthusiasm was created and several at each camp collected many more than the required number, thus making the judging and awarding of prizes very close. Each club member's camp attitude was recognized and, in many cases, had to be the deciding factor in awarding the prizes.

CAMP DATA. There were ten camps conducted in Missouri in 1931. These camps consisted of 7 district and 3 county camps which were attended by 1,115 4-H club members, leaders and assistants from 4-H

counties of the state. The average camp was conducted for a period of three days. Cabins and tents were used as living quarters and in a few cases Boy Scout and Y. M. C. A. camps were used. This made it possible to have buildings for our laboratory work. When no buildings were available, long tables were used out in the open. The largest camp held had an attendance of 265 persons. The average attendance was 111.5 persons per camp. The percentage of satisfactory completions was very high considering the number in each camp and the fact that it was the first time for a great number of them to study insects. Those who assisted in conducting this study were George D. Jones, extension specialist in entomology, Dr. Leonard Haseman, head of the Department of Entomology, Robert Meffert, a graduate student in Entomology, and Paul H. Johnson, Assistant in Entomology.

CONCLUSION. This was the second year for nature study in 4-H Club camps in Missouri, forestry being the course studied last year. According to T. T. Martin, 4-H Club leader in the state, the work seemed to be of a type which aroused interest and was at the same time valuable information to be given to farm boys and girls. He was very enthusiastic about the work and was favorably impressed.

Many of the county agents said it was valuable instruction and that it would be far reaching in its influence. As a whole it seemed to be well liked and we feel that it was a successful attempt in teaching entomology to the members of the 4-H Club camps in Missouri.

REACHING MORE PEOPLE

By A. B. GRAHAM

We may count our losses, one by one—we count them also on the basis of 6,500,000 farms, whose grasshoppers, ants, and other six-legged creatures eat them out of house and home. Our checks written, month by month, are supported by the revenues from 123,000,000 people. This of course includes the 30,000,000 who live on farms. We accept their money and we count the losses on total farms. The one great question that arises in my mind is, "What is done to reach the masses who suffer the losses and who help to pay our salaries?" Our job then is one not of extension entomology alone—it is one of dealing with people in such a way that we make them want our work and feel an intense need for our methods of control or prevention.

We may learn of the habitat, life history and other peculiarities of the mosquito and the common housefly, and the behavior of other insects,

but the one form of animal life that challenges us is "What to do with *Homo sapiens?*" He is the one who is feeling the losses, he is the one who is paying for investigation to arrive at control measures and it is he whom we should make want the particular thing he is paying for.

Human beings are like other forms of life; some of them are more inclined to seek things for themselves, others delaying for what reason we may not know, but our job is to learn through what avenues man is to be reached.

We may say to him that it pays in money to control insect pests, and if he feels the need with sufficient sharpness he will respond because of such an appeal. This may be true of grasshopper control, the chinch bug, the curculio, the codling moth and various other forms whose chief business seems to be to eat up what man would like to have but our appeal must be of a different kind when we say that screens prevent flies touching our food, draining the marshy place eliminates mosquitoes, the killing of rats prevents the carrying of plague. These appeals are of the nature of saving life or prolonging it.

If we appeal to the good farmer, whose example is worthy of following, we desire him to act as a demonstrator and show by an object lesson on his own farm that what he has done is worthy of following because he did it. This appeals to his ego. We all may be in a degree modest, but this appeal reaches very deep within most of us.

Not the same kind, but very like it, is the appeal to one's altruistic nature. That is a demonstration which may be put on by the farmer because he likes to be known as a person who will help others. There is a still different type of appeal that is exemplified when we say—"Mr. Jones, an excellent farmer across the way, is getting splendid results with a particular kind of material applied in a certain way." The mere fact that we refer to Mr. Jones emphasizes that his example should be imitated, so we have the appeal to our nature to imitate those who are worthy of imitation.

So much for the appeals. No person learns what is not within his field of understanding. It devolves upon us to work out such methods as are practicable for the masses, whose funds may be limited, or who may be limited as to their understanding of manipulation. They must be able to do the thing some easy way so that their muscular habit patterns or practices are not interfered with too much. The materials must be available and all of our circular letters, bulletins, news items, and even legends to pictures must be within their understanding, for we are trying to reach the masses, not increase vocabulary. Vocabulary building will take care of itself somewhat if we are an adept about using synonyms.

The question often arises in the mind of the farmer—"Shall I try this new thing and suffer all sorts of embarrassment and discomfort, or shall I go on in the same old way and suffer my losses?" You can answer as well as I, what he will do.

We must approach them somewhat with the idea of getting their attention. A little exhibit, if it is nothing more than flies in a glass case where people can see them going from things quite offensive to different kinds of food. Great attention getters are the movie, the radio, newspaper articles about the success of one individual, provided it be the right individual. Such things repeated in different forms, if nothing more than slogans and happily prepared rhymes, dramas, etc., quicken both the attention and desire of people to do what the extension teacher has in mind.

It may be quite some time before it is accepted but if repeated, it will develop interest. Interest is indicated by such questions as "Will you send me the recipe? Can I get a bulletin? Is there any book published on the subject?" And perhaps a lot of other inquiries that are being presented by telephone, by letter and the newspapers. In putting on our demonstrations it should also be kept in mind that the persons, or some person of the group observing the work, should be invited to participate. Perhaps it may be nothing more than to mix materials or to operate a pump or to prepare poisoned bran. It matters not what it is so it eliminates fear and establishes confidence in themselves to carry out the instructions of the demonstrator. Then the demonstrator can leave and there is at least one individual, if not more in the community, who may carry on. Attention, interest and desire may all be stimulated through various means and agencies, but sometimes to little avail. There must be a continuity of the idea running all through the different features used to reach people, as well as variation in the means and agencies used.

But after all, we may stop with a dull thud and say to ourselves—"Nobody is carrying these practices out." The great barrier in the way is perhaps because they have not clearly in mind the directions for the use of material, or the material itself may not be easily available. The price may be beyond their reach. The demonstrations may be put on in a direction from their homes contrary to their habits of travel. The newspaper of greatest circulation may not be the one they subscribe to. Difficulties should be eliminated by the county agent and the specialist in an organized way, after an analysis of barriers is made.

Another difficulty in reaching people lies in the fact that much insect control work is in the nature of a personal service for one who has strong initiative and expresses his desires to us; but our job as extension agents

is to make people want to know about control or preventive measures. Our job is to so organize and prepare our material in various forms that we may the easier cause them to want it and use it. We must study problems with them in an organized way. The presentation of our work should be largely through some temporary organization at least, which has been formed by the county agent and the extension entomologist, that through the demonstration and by means of the material distributed, masses of people can be reached.

There is a legitimate field for the extension entomologists through various businesses and industries, the manufacturer of spray materials, the manufacturer of spray and dusting outfits, the local dealers in supplies, even to the mail order houses, and through such agencies we may learn of the spread of influence, because of increased sales and sales in new territory.

Investigational work will in the end receive support from the general public to the degree that insect control measures are extended to the masses, and our positions, as well as our salaries, are at the same time more fully justified because of the general acceptance by the people.

Symposium on Orchard Spray Service

ORCHARD SPRAY SERVICE

By M. P. JONES, *Washington, D. C.*

There is no other piece of entomological or pathological work which has continued to grow since its inception like orchard spray service. It is one thing which the extension service can point to as a real accomplishment. Its value can be measured by the percentage of fruit free from insect and disease injuries at harvest time. Comparisons among orchards which were sprayed according to varying spray programs, show conclusively that orchardists are justified in carrying out a thorough spray schedule.

There is no half way for a spray program. When dealing with insects or diseases one can not apply half the normal sprays and expect to get half of the fruit clean. Partial sprays may be comparable to no spray at all. Perfectly clean fruit is desired but it is not always the most economical to produce. The cost of preventing injury to the last two or three per cent is often prohibitive. Effective spray service necessitates the closest cooperation between the entomologists, pathologists, weather bureau officials, county agents and orchardists.

There are different methods of carrying on spray service. The choice of methods is influenced by climate, the relative importance of the crop and the training and experience of county agents and orchardists.

In mountainous country temperature varies so much that a blanket recommendation for spraying a large area cannot be given. For instance tree and insect development on the opposite sides of a mountain may vary from one to two weeks. There is also a marked difference in the time of development on the top of the hill and in the valley. In less rolling country with more uniform conditions several counties can be placed in one zone. Within one of these zones the factors which influence the time of spraying will be near enough the same, in the average season, that a blanket spray recommendation can be given for the zone. Large bodies of water may influence the temperature so that nearby orchards may require special spray service information.

In counties where fruit is a major crop the county agents are usually well versed in control of insect and disease pests of the orchard. They are competent to advise the time for applying the different sprays with very little help from the specialists. In other counties where fruit is a minor crop, county agents are not so well informed, and the specialists have to take a large part in the service.

There is much difference in the alertness of the orchardists. The more progressive ones are familiar with the factors which influence spray service. If forced to do so they could handle their own situation with but little assistance. On the other hand there are orchardists who have followed the spray chart after a fashion and have obtained fair returns for their efforts but know little or nothing of timely spray service. There is much need for educational work with this group before it would be on a plane with the better informed. It is true that there is no sharp dividing line between these two types of growers but there are growers representing all classes from the poorest to the best.

The "grow your own" campaign has led to much discussion over the home orchard situation. The conclusion reached in many conferences is that when commercial orchards are present there is no justification for the few home fruit trees. However in areas far removed from commercial orchards farmers may be justified in producing sufficient fruit for home consumption. It is the feeling that in areas where fruit is plentiful the non-orchard farmer can purchase apples of the quality he would produce for much less than the cost of production. In seasons when the commercial fruit crop was light, the home orchardist's trees would not even bear fruit but in spite of this the home economists tell us

that if fruit is not produced on the premises too often it does not get into the diet.

It is the hope that this symposium will be of use in organizing spray service projects in other states.

THE SPRAY SERVICE IN NEW YORK

By C. R. CROSBY, *Ithaca, N. Y.*

The spray service is a result of a serious attempt to look at the fruit grower's insect and disease problems realistically. The idea is to substitute concrete for general information and to give the grower this information when it will be most useful to him. Under the older system the grower was supposed to obtain what information he could from winter meetings or from bulletins prepared far in advance of the spraying season. He was left to adapt this information as best he could to the peculiar conditions of the season, including such varying factors as climate, the abundance of insects and the prevalence of diseases. The aim of the spray service is to furnish from time to time, as needed, reliable information based on a thorough knowledge of conditions as they exist at the time and in the particular area. In the beginning the objection was raised that activities of this kind could hardly be called educational. The obvious reply was that if giving general information at an inopportune time was educational then the giving of definite and practical information when wanted would have still greater educational value. The latter view has prevailed and the spray service has now become an integral part of the extension activities of the State.

The spray service was first developed for fruit growers but recently it has been successfully extended to potato growers and in a limited way to vegetable growers.

Under the plan followed in New York the spray service is conducted jointly by the departments of Entomology and Plant Pathology. The work is conducted directly by the subject matter specialists of these departments and not through the departments of Pomology or Vegetable Gardening. This arrangement is in the interest of simplicity and efficiency; there is less slack to be taken up and less machinery to keep oiled. The plan has been to decentralize the work as much as practicable and to give the county agent full responsibility for conducting the work in the county. Under this system the success of the work depends largely on the ability and training of the men serving as county agents. That this system has been successful speaks well for the high quality of

the men selected for these positions. Many of the New York counties employ more than one agent. In some the spray service work is conducted by the agent and in others by the assistant agent. In this paper "county agent" refers to either.

Preparation for the spray service begins at the winter meetings of fruit growers. Their problems are fully discussed and plans laid to meet the situation in the most effective way. The service has been in operation long enough now so that a large proportion of the growers understand the system and know what to expect from it and how to utilize it to best advantage.

To give the agents the necessary subject matter background, a week's school is held at the College in early March at which all the problems of insect and disease control they are likely to encounter are thoroughly discussed. The discussion of these problems is led to a considerable extent by members of the Experiment Station staff who are actively engaged in research work along these lines. This insures a full, thorough and frank consideration of all the more difficult questions of control. This conference is of material benefit to both groups of workers and interest never lags. A similar mid-season one-day conference is always held about June 1st.

In each county the agent sends the information to the growers largely by letter or card. The telephone relay system formerly so popular is now used only in emergencies if at all. The usual practice is to send out a rather general letter a few days before each spray, giving the formula to be used with suggestions as to methods of application and to follow this with a card when the time actually arrives to make the application. The letters may be sent to all the growers in the county at one time and the cards may be mailed separately for the different zones of the county at the proper time for applying the spray. In timing the sprays the agents utilize every possible source of information. The telephone is used freely to get in touch with the Weather Bureau, with the College and Experiment Station workers and with agents in nearby counties. The long distance telephone charges incident to timing a single important spray in the four lake counties of western New York often amounts to between $30 and $40, a trifling sum compared to the value of the crops at stake.

In order that the sprays may be timed accurately and that no contingency be overlooked, it is necessary that the agent spend most of his time in the field. Due to differences in elevation and proximity to large bodies of water in some of our counties, there may be differences of several days or even weeks in the time of the opening of fruit buds,

hatching of eggs, and development of broods of insects. All these things have to be taken into consideration in conducting an effective spray service. Training, experience, ability to observe closely and accurately, coupled with sound judgment are the qualities that make the successful spray-man. It is an exacting task, the responsibilities are heavy but there is a lasting satisfaction in guiding a group of several hundred growers through the season's problems to a successful harvest.

The spray service is greatly strengthened by the cooperation of the experiment station workers having field experiments in the territory. These investigators often have valuable information as to the time of emergence, egg laying and maturity of important pests; all of which they make immediately available to the county agents. In this way much duplication of effort is avoided and the service improved.

Our spray service has always had the hearty cooperation of the U. S. Weather Bureau. A special forecast is prepared each evening and sent to each county agent. It reaches the county about 11 P. M. and may be used as a basis for spray warnings issued early the next morning. These forecasts are extended beyond the usual 48 hour period wherever possible and are so worded that the agent can determine the percentage of certainty in the forecaster's mind as to the accuracy of the predictions. This weather service has been of inestimable value to the spray service; in fact it would be almost impossible to get along without it.

The agent also conducts a number of seasonal demonstrations in orchards in different parts of the county so located as to be representative of conditions in the various zones of the area. In these orchards certain rows at least are sprayed according to the recommendations of the spray service and the results obtained serve as a check on the value of the advice given. These are sometimes known as criterion orchards

The duties of the subject matter specialists in connection with the spray service are definite and varied. Their first duty is to keep all pertinent information on the control of insects and diseases fully summarized and in available form for the use of the field workers. To meet this need in part bulletins have been prepared on the control of insects and diseases of orchards, of vegetables and of potatoes. These are published in small editions so that the supply becomes exhausted within a year. They are then revised, brought up to date and reprinted. The specialists arrange and conduct the schools and conferences for the field men and maintain contacts with the research workers of the experiment stations. They also issue the weekly news letter sent to the

field men each Monday throughout the season. They are in the field most of the time during the spraying season, visiting the counties to study local conditions and to assist the agents in deciding what recommendations to send out. They have no administrative relation to the county agents; technically they merely furnish subject matter assistance. The spray service is a cooperative enterprise to which several groups contribute in different ways. The agents are responsible for the work in the counties, the subject matter specialists for the soundness of the information given out, the central farm bureau organization for the selection of personnel and general administration, the experiment station workers for assistance in meeting new problems, the weather bureau for special forecasts and the growers themselves for intelligent utilization of the advice given out.

THE OHIO SPRAY SERVICE

By T. H. PARKS, *Ohio State University*

The Ohio Spray Service to fruit growers is given jointly by the extension entomologist and extension plant pathologist. The service given includes information about sprays and spray materials, but has to do chiefly with the proper timing of the apple scab and codling moth sprays.

The timing of the dormant and petal fall sprays is fixed by tree development. For these sprays information letters are sent to the growers and these letters carry recommendations concerning materials to use.

The two chief divisions of the codling moth spray service consist of: (a) getting information from the field about insect development and, (b) disseminating information to the fruit growers. The information about codling moth developments is secured from five widely separated commercial orchards, each of which is located at a strategic point to serve the growers of that region. The entomologist directs the work at each station, but the daily observations are made by county agents specially trained for the work, students serving as special spray observers, and an experiment station representative. At each station several hundred overwintering codling moth larvae are collected during the spring from bands placed on tree trunks. These larvae are placed in a screen cage which is set up under a typical tree chosen for the observation point. A thermometer is hung near the cage and observations are begun at about the time of petal fall. The observer records the moth emergence and the 7 p. m. temperature each day. This time is chosen

because just before sundown is known to be the time of day when the moths become active and begin to deposit eggs. This information for each observation point is sent each evening to the extension entomologist at Columbus. He has assembled the next day these records of moth emergence and evening temperature for each of the five widely separated localities. From these records the time for applying the cover sprays is determined and the information sent to the county agents. In determining the spray date, the evening temperature at each station receives as much consideration as the volume of moth emergence. Several days of low temperature following the first wave of moth emergence leads us to disregard these moths in making our spray recommendations. In such cases the first cover spray will be postponed until about ten days after the temperature again becomes favorable for egg laying. Under such conditions the usual "3 weeks" spray may become a "5 weeks" spray. On the other hand, should an extended period of warm weather follow the first wave of moth emergence, the 1st cover spray might be advised as early as two weeks after the calyx cup spray. When such is the case, an extra cover spray may be advised later against the first brood of worms. The need for such extra sprays depends upon, (1) the distribution of emergence through May and June, and, (2) the abundance of overwintering codling moth worms in the community. Such extra sprays have been advised for certain localities during each of the past three years.

The period of time between petal fall and the first cover spray varies not only with the season, but in different localities during the same season. For example, the sundown temperatures during the four weeks following petal fall have been consistently lower in Ottawa County, Ohio, than at any other observation point. This may be due to the influence of Lake Erie which almost surrounds much of the fruit area of this county.

The second brood codling moth spray is timed at each location through emergence of moths from banded trees. The evening temperature is not considered for this generation, as the temperature at that time is always favorable for egg laying.

To guard against error in interpretation of the data, the moth emergence in the cages has been carefully checked against that occurring on tree trunks where the larvae have remained undisturbed. These emergence curves are sufficiently identical as to give us confidence in the method.

The spray information is sent to the growers (a) through letters sent from the county extension office and (b) radio messages sent at regular

periods from three Ohio broadcasting stations. Radio broadcasting arrangements are made sufficiently in advance so that the exact time of these broadcasts are known to the growers. The letters and radio talks are prepared by the extension entomologist, although the letters carry the signature of the county agent and are usually sent to him in quantity ready to be mailed to the fruit grower. The radio talks are read from Cleveland and Cincinnati by the local county agents and from Columbus by the entomologist.

In order to check upon the results secured in orchards following the spray service, the county agent is instructed to distribute spray record cards. Any grower, who will agree to keep an accurate record of his spray operations, is given a record card. On this he records age and variety of trees, type of spray rig, pressure developed, time of applications, quantity of spray applied, strength of insecticide and fungicide used and weather conditions at time of application. Just previous to apple picking, the extension representative visits this grower and carefully checks on the percentage and types of insect and disease blemishes on each of his commercial varieties. The average percentage of clean fruit for the entire orchard is then determined. If this record shows a high percentage of insect or disease blemishes, the cause is usually found in studying the record he has kept. In each case the grower receives a letter from the specialist suggesting changes in the spray program that might correct the trouble. In many cases no criticism of the grower's efforts can be made, for the percentage of clean fruit has frequently averaged 96 or better. To such growers a letter of commendation is sent.

Apple spray records were kept and returned by 98 growers during 1930 and by 94 growers in 1931. The average percentage of clean fruit produced in these orchards was 86.4 in 1930 and 89.8 in 1931. During both of these years codling moth was quite serious. Apples which bore the smallest blemish, caused by either disease or an insect, were classed as imperfect. In many cases such fruit could be graded as U. S. No. 1. The percentage of marketable fruit was, therefore, much higher than these figures indicate.

We have found the growers ready cooperators in the spray service work and eager for the latest information. It has been our aim to do our best in furnishing the correct information to growers, but not to impose our recommendations upon them if they prefer to follow their own judgment. The surprise has been that so many of them call over the telephone if they have failed to hear the radio message or receive their letter.

Proceedings of the Third Annual Paper-Reading Session of the Eastern Branch of the American Association of Economic Entomologists (*Second day*)

Friday, November 20, 1931

THE PROBLEM OF CODLING MOTH CONTROL[1]

By Thomas J. Headlee, Ph.D., *Entomologist, New Jersey Agricultural Experiment Station*

Abstract

The broad outlines of codling moth control were set forth by Mark V. Slingerland thirty-three years ago. Since that time the primary improvement has occurred in the development of control through the use of stomach poison insecticides and the secondary in the use of scraping and the development of lethal bands. The efficiency of stomach poison insecticidal applications varies inversely as the density of the codling moth population. With annual crops of apples, temperature favorable to the production of many broods, weather favorable to heavy oviposition activities, and inadequate practice of known measures of control, such dense populations of codling moth can be built up that the practice of no one or all of the ordinary measures of control will serve to secure good commercially clean crops. Some new method of administering cheaply and promptly a knock-out blow to the codling moth should be sought. The only time when all individuals of the codling moth are in the same stage for a considerable period of time is during the period of hibernation. It is probable that this is the most promising point of artificial attack. Pine oils have shown considerable promise for this purpose and have produced some marked reductions in the density of codling moth populations. Other agencies, such as gas and heat, should be tried.

The problem of codling moth control is now and has always been a problem of reduction in codling moth population. In general the most widely used method of control has been the application of stomach poison insecticides to fruit and foliage where the insect can get them in the process of attempting to infest apple fruit. This method has been successful in inverse proportion to the density of codling moth population. That stomach poisons were not the only early methods used is evidenced by data set forth in Cornell University Experiment Station bulletin 142 by Mark V. Slingerland in which destruction of emerging moths in storage rooms, jarring or picking of infested fruit, destruction of wind-falls, and banding of tree trunks and branches were recommended. Slingerland's bulletin was published in the year 1898, or 33 years ago. Today, codling moth control is being sought along the same

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

general lines, the primary advances being in materials and application of stomach poisons and secondarily in tree scraping and codling moth banding.

Where the codling moth population is low, spraying usually proves satisfactory as a sole method of control. Where population builds up into large proportions the other methods mentioned, in part or in whole are added to the spraying process. Comparatively recent years have shown instances in which codling moth populations have increased in certain orchards and certain areas to a point where no one or all of the methods mentioned are sufficient to bring 95 to 98% of the picked fruit through free from codling moth injury.

Process of Developing Dense Populations. It may be well at this point to inquire into the conditions which lead to the development of these enormous populations of codling moth. The factors concerned are: (1) many broods; (2) high continuity of fruit production; (3) practical absence of parasites and predators; (4) inadequate practice of artificial measures of control.

Every additional brood of codling moth means a geometric multiplication in point of numbers and consequently the larger the number of broods the greater the density of the population is apt to become. A sufficient annual supply of apple fruit is necessary for the building up of a great population of codling moth. Failure of food supply at more or less regular intervals will prevent the normal increase taking place. Obviously, the fewer parasites and predators the larger will be the number of codling moths reaching maturity. The inadequate practice of artificial methods of control is a necessary and final step to permit the codling moth to reach its maximum abundance.

In New Jersey the number of broods ranges from one in the mountainous section of the northwestern part of the state to two full broods in the coastal plain section of the southern portion of the state. The continuity of fruit production is excellent for the writer has not seen in nineteen seasons one season in which there was not a sufficient supply of fruit set for codling moth economy to proceed almost unhindered. Parasite population during these nineteen seasons has always been small and of little account. Predators have occasionally been active but never in sufficient numbers to produce a real reduction. Like every other apple growing section of the United States inadequate practice of measures of control is the rule rather than the exception.

Example of the Process. The writer will take the instance of tremendous increase in codling moth populations with which he is most familiar. In the summer of 1913 in a small block of old trees in the Glass-

boro district, during a series of dusting and spraying experiments, the untreated fruit, including both dropped and picked fruit, showed only 4% injury by codling moth. By the year 1925 a 100 acre block standing immediately adjacent to the block treated in 1913 showed 55% of the

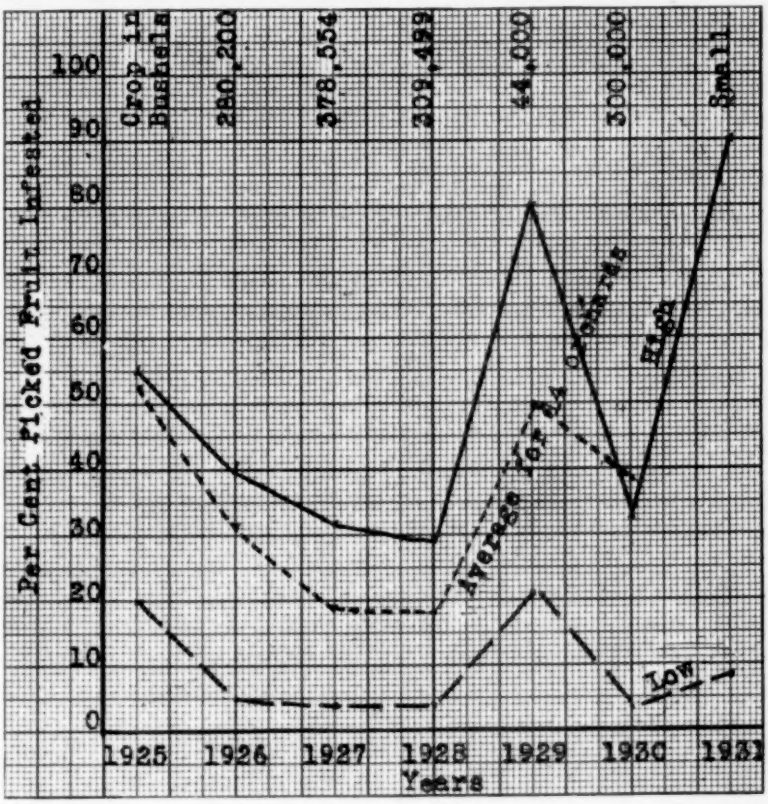

FIG. 32.—Course of Codling Moth Infestation.

picked fruit infested by codling moth, under the ordinary spraying conditions then obtaining. In 1926 this same block showed 40% of the picked fruit infested by codling moth under rather more intensive spraying conditions. In 1927 this same block showed 31.6% of the picked fruit infested by codling moth again under intensive spraying conditions. In 1928 this same block showed 29.7% of the picked fruit infested by codling moth. In 1929 this same block showed 80.0% of the picked fruit infested by codling moth. In 1930 this same block showed 32.5% of the picked fruit infested by codling moth and in 1931 this

block showed 90.0% of the picked fruit infested by the codling moth. In 1930 and 1931 scraping and banding were used in addition to spraying. The spraying practiced in 1929, 1930 and 1931 was probably considerably less intensive than that practiced in 1926, 1927 and 1928. Figure 32 illustrates graphically the course of infestation in this orchard, in the average of the district, and in an orchard in this district where commercial control was high.

It is believed that the weather, particularly the temperature factor thereof, has been a matter of large importance in codling moth economy, increasing the reproduction possibilities if favorable and reducing them if unfavorable. It was thought worthwhile to determine whether there existed any difference in favorableness of the weather during the different years that this 100 acre block was under observation. The temperature factor of the weather, influences the oviposition activities of the adult codling moth. In an examination of this effect, a determination of the number of evenings and mornings when the temperature stood 62° F or above was made. The 62°F limit was adopted because activity below that point is small. Egg laying has been observed as low as 54°F but that which occurs between 54 and 62°F is very small in amount. Egg laying begins, in the evening at least, when the light intensity has fallen to thirty foot candles and continues until the merest fraction of a foot candle, really not susceptible of measurement on a foot candle meter, has been reached. After that point the adult moths cease activity. The results of this study are set forth in Table 1.

In the period covered by this table there are three years omitted, namely 1920, 1921 and 1922. They are omitted because the available temperature data were too incomplete to justify using them as a basis for study.

The total number of mornings and evenings favorable to oviposition by the codling moth in April, May and June are set down separately because during that period the first brood is active. The total number of mornings and evenings favorable to codling moth oviposition during July, August and September are likewise set down separately because during that period the second brood is active. In order to bring out the correlation and to permit a reasonable interpretation of Table 1, Table 2 is now inserted.

Thus it appears that in 1926 the weather was considerably less favorable to codling moth oviposition than the average of the fifteen year period under consideration. In 1927 the weather was still less favorable. In 1926 codling moth infestation in the picked fruit from this orchard dropped 15.5%. In 1927 there was still a further decrease of 8.4%. In

TABLE 1. STUDY OF THE MORNINGS AND EVENINGS AVAILABLE FROM THE TEMPERATURE STANDPOINT TO OVIPOSITION BY THE CODLING MOTH THROUGHOUT A PERIOD OF FIFTEEN YEAR

	Years																											
	1914		1915		1916		1917		1918		1919		1923		1924		1925		1926		1927		1928		1929		1930		1931	
Months	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
April 15–30	0	1	0	10	0	1	0	4	0	3	0	0	0	4	0	1	0	4	0	3	0	4	0	1	0	0	0	1	0	2
May	2	21	2	10	2	20	0	9	5	25	1	15	0	10*	0	6	0	12	1	16	0	10	0	17	3	20	2	18	2	16
June	9	26	9	25	5	23	14	28	7	26	6	27	16	30	9	22	21	30	2	20	3	22	14	23	15	26	15	30	8	29
July	20	31	22	31	24	31	28	30	19	30	23	31	16	31	17	31	16	31	21	29	16	31	28	31	19	30	22	31	28	31
August	20	31	21	30	21	29	23	31	20	30	15	31	14	30	17	30	17	31	21	29	8	27	25	31	11	29	10	30	25	30
September 1–15	4	8	11	15	8	13	3	9	4	14	7	14	4	12	3	10	11	15	2	13	4	14	7	12	9	12	7	15	9	15
Total	55	118	65	121	60	117	68	111	55	128	52	118	50	117	46	100	60	123	47	110	31	108	74	115	57	117	56	125	72	123
Totals of mornings and evenings	173		186		177		179		183		170		167		146		183		157		139		189		174		181		195	
Total — April, May & June.	11	48	11	45	7	44	14	41	12	54	7	42	16	44	9	29	21	46	3	39	3	36	14	41	18	46	17	49	10	47
Totals of mornings and evenings	59		56		51		55		66		49		60		38		67		42		39		55		64		66		57	
Total — July, Aug. & Sept.	44	70	54	76	53	73	54	70	43	74	45	76	34	73	37	71	39	77	44	71	28	72	60	74	39	71	39	76	62	76
Totals of mornings and evenings	114		130		126		124		117		121		107		108		116		115		100		134		110		115		138	

1 = Number of mornings. 2 = Number of evenings. *Records incomplete.

TABLE 2. ANALYSIS OF THE DATA IN TABLE 1 CORRELATED WITH PERCENTAGES OF PICKED FRUIT INFESTED BY THE CODLING MOTH

	Number of mornings and evenings favorable for codling moth oviposition in relation to the 15 year average[1]				Number of mornings and evenings during April, May and June favorable to oviposition in relation to the 15 year average[2]				Number of mornings and evenings During July, August and September favorable to oviposition in relation to the 15 year average[3]				Percentage of Picked fruit infested	
	Periods		Percentage		Periods		Percentage		Periods		Percentage			
Year	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	High	Low
1914	—	0.2	—	0.1	4.1	—	7.2	—	—	4.3	—	3.6	—	—
1915	12.8	—	7.3	—	1.1	—	2.0	—	11.7	—	9.8	—	—	—
1916	3.8	—	2.1	—	—	3.9	—	7.1	7.7	—	6.5	—	—	—
1917	5.8	—	3.3	—	0.1	—	0.1	—	5.7	—	4.7	—	—	—
1918	9.8	—	5.6	—	11.1	—	20.2	—	—	1.3	—	1.1	—	—
1919	—	3.2	—	1.8	—	5.9	—	10.7	2.7	—	2.2	—	—	—
1923	—	6.2	—	3.5	5.1	—	9.2	—	—	11.3	—	9.5	—	—
1924	—	27.2	—	15.7	—	16.9	—	30.7	—	12.3	—	10.3	—	—
1925	9.8	—	5.6	—	12.1	—	22.0	—	—	2.3	—	1.9	55.5	20.0
1926	—	16.2	—	9.3	—	12.9	—	23.4	—	3.3	—	2.7	40.0	5.0
1927	—	34.2	—	19.7	—	15.5	—	28.2	—	18.3	—	15.4	31.6	4.1
1928	15.8	—	9.1	—	0.1	—	0.1	—	15.7	—	13.2	—	29.7	4.0
1929	0.8	—	0.4	—	9.1	—	16.5	—	—	8.3	—	7.0	80.0	21.0
1930	7.8	—	4.5	—	11.1	—	20.2	—	—	3.3	—	2.2	32.5	3.6
1931	21.8	—	12.5	—	2.1	—	3.8	—	19.7	—	16.6	—	90.0	8.0

[1]Fifteen year average is 173.2.
[2]Fifteen year average for months of April, May and June is 54.9.
[3]Fifteen year average for months of July, August and September is 118.3.

1928 the weather was about average for the first brood and considerably more favorable for the second brood yet the infestation dropped 1.9%. In 1929 the weather was again more favorable than the average for oviposition by both broods. The crop in this orchard was well nigh negligible, being only 945 bushels, and the infestation shot up to 80%. In 1930 the weather was more favorable than the average for the oviposition of the first brood and somewhat less favorable for the oviposition of the second brood. The crop was large and the infestation reached a low point. In 1931 the weather was somewhat more favorable for the first brood and much more favorable for the oviposition of the second brood. The crop was relatively small and the infestation shot up to 90%.

When differences in control in the low and high infestation orchards are considered in conjunction with the facts that the low and high orchards are in the same district and that the low orchard is composed of trees fully as old and considerably larger than the high, the conclusion that the difference in infestation is due to inadequacy of artificial treatments in the high infestation orchard is inevitable.

The question is: "Must we permit a grower who cannot make his applications with sufficient thoroughness to be put out of business by the apple worm?" Stated another way the question is "Can we not find some method of promptly reducing the codling moth population to a point where treatment will enable the grower to grow a clean crop within the limits of a single year?"

ANALYSIS OF THE PROBLEM OF CONTROL. The problem that requires solution is one of securing an inexpensive and prompt reduction of the codling moth population.

Biological Control. Throughout the period of the writer's experience in New Jersey the factor of parasites and predators of the codling moth has been practically negligible. The common parasites and predators present in the apple growing sections of the country are apparently present here but never in sufficient numbers to exert more than a negligible influence upon the density of codling moth infestation. There does not, therefore, seem to be much hope in any effort to utilize natural enemies. This point of view is re-inforced by the status of codling moth populations in Europe where the factor of biological control does not seem to be particularly important.

Starvation Control. During his experience in Kansas the writer has seen crops of apples in bearing orchards completely eliminated by frost in the neighborhood of the blossoming time. Such orchards, in his experience, the following year showed only the merest fraction of codling moth infestation. It seems, therefore, that if the crop were com-

pletely destroyed by artificial means about blooming time, a condition would be created whereby the codling moth population of that orchard would be reduced to the merest fraction of what it had been the year before. Financially, in many ways, this scheme would seem to have a possibility of great practical value. The cost of killing the bloom would be small. The spraying necessary to protect against fungus diseases of the foliage and leaf feeders would be small and the cultivation required in the orchard would likewise be reduced to a low point. Furthermore, the succeeding crop would probably exceed the normal by about 50%. The difficulty of such a procedure is found in the psychology of the grower who will not readily accept the undoubted reduction in his gross income which would occur for the season during which the crop was destroyed.

Scientifically, the question concerning the value of such a procedure lies in its efficiency in reducing the codling moth population. Without doubt some codling moth always succeed in escaping the starvation effect of such a procedure and without doubt there is a certain amount of movement of codling moths from adjacent apple orchards. The extent to which such a procedure would be efficient, in view of the re-infestation factors above mentioned, has never been accurately determined but in the writer's opinion the chances are that the efficiency of such a treatment would be high.

Destruction in Hibernation. Assuming that crop destruction of one reason or another is impractical, we have next to examine the possibility of administering a body blow to the codling moth population by other means. Obviously present methods of summer treatment are bound to prove inadequate in instances where the codling moth population is sufficiently dense. Of course, it is possible to produce large reductions by more thorough spraying practice, especially when accompanied by the use of materials which hold the stomach poisons on the trees for a longer period of time, but unfortunately the best that can be anticipated from the summer spraying is a slow reduction of population requiring a period of several years to arrive at its maximum and unfortunately this process appears to be favorable to the development of what seems to be a considerable degree of resistance on the part of the codling moth larvae, and for that matter any other stage of the insect, to the materials used against it in the treatments.

The ideal method of producing this reduction would be a single artificial treatment which would destroy 90 or more per cent of the population by one stroke. The only period of the year during which the insect is for a long period of time all in the same stage and, therefore, when such a single treatment might possibly be applied, is during the dormant

period. The first question is whether the insects, during that time, are all located at points where they can be reached. Under New Jersey conditions, at least, practically 100% of the overwintering codling moth larvae in apple orchards are found on the apple trees. This would, of course, not be true if storage buildings were located in the orchards or wood debris were allowed to lie on the ground in the orchard, whether this debris were old apple containers, prunings, or what not. Two years ago a question was raised by one of our men as to what extent the codling moth pass the winter on the ground in the leaves under the trees. Two large sacks of leaves were raked together and enclosed in a cage. From this mass only one codling moth adult emerged. Further studies of this sort in relation to weed growth will be made during the present dormant season. Investigations in some other parts of the country indicate a larger amount of hibernation in debris on the surface of the soil. Practice of a reasonable degree of orchard sanitation and culture would probably eliminate these factors almost entirely. Assuming, therefore, that destruction of an extremely high percentage of the larvae overwintering on the trees would afford the reduction desired we have next to inquire as to what materials may be used for this purpose. Gases, live steam, and penetrating oil treatments suggests themselves as possibilities. The third of the three mentioned, namely penetrating oils, are the only ones with which we have done any work, although we are now examining the possibilities of the other two. Even with our present crude methods of applying penetrating oils we have been able in orchard block treatments, involving about 400 trees, to obtain sufficient destruction of overwintering codling moth to reduce the infestation by the first brood fully 50%.

Summary and Conclusions

1. The primary consideration in the control of codling moth is a satisfactory reduction in codling moth population.

2. So long as the codling moth population is low well known orchard spraying processes seem adequate for its control.

3. Larger populations can be controlled by spraying plus practices of orchard sanitation.

4. Codling moth populations of such size can, and sometimes do, develop in commercial orchards that satisfactory control cannot be obtained by the orchardist utilizing all of the measures of spraying and orchard sanitation.

5. Codling moth populations held under commercial control by these methods are so large that under unusually favorable weather conditions satisfactory commercial control may be lost.

6. A practical method must be found by means of which the codling moth population in an orchard, no matter how high its density, can be so reduced within the limits of a single season that excellent commercial control can be secured at a practicable cost.

7. In view of the fact that under good orcharding conditions practically the entire overwintering brood is present in the larval stage on the apple trees of the orchard, it seems logical that this overwintering brood should be the stage attacked for this purpose.

8. Pine oils have been shown to have high destructive powers against this stage of the codling moth without apparent injury to the trees and their possibilities for this purpose should be fully investigated.

9. Pine oils do not represent the only possible means for attacking the insect in this stage. It is assumed that gases might be used and that heat coming from live steam might be employed.

10. This problem of reducing codling moth populations by artificial means is one to which all of us, in whose territories this tendency to build up dangerous densities makes its appearance, must give careful attention because the factor of biological control of this insect seem to be well nigh negligible.

COMPARISONS BETWEEN NICOTINE TANNATE AND ARSENATE OF LEAD AS CODLING MOTH POISONS[1]

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ABSTRACT

Nicotine tannate kills the more mature eggs and the young crawling larvae of codling moth by contact. Sprayed apple foliage retains its toxicity to codling moth larvae for at least 21 days. Nicotine tannate appears to be more toxic as a stomach poison to codling moth than arsenate of lead. Success with this insecticide depends on its proper preparation and use and directions for its preparation are given.

Nicotine Tannate as a substitute for arsenate of lead has been tested for several years in New Jersey and accounts of this work have already been published; Headlee et al (1930) Filmer (1931). A great many chemical analyses of foliage treated with this material have been made

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

and it has been found that under New Jersey conditions some 75% of the nicotine has usually disappeared at the expiration of ten days. However, there is always a determinable amount present for thirty days or more, the quantity decreasing to a fraction of a milligram per square foot of leaf surface. These small residues were at first considered negligible, but continued field experience indicated to Dr. Headlee that Nicotine Tannate was giving *better* control of codling moth *Cydia* (*Carpocapsa*) *pomonella* L. in southern New Jersey than arsenate of lead. He, therefore, assigned to the writer the problem of studying the toxicity of Nicotine Tannate to the eggs and young larvae of codling moth.

Source of Codling Moth Eggs. Codling moth larvae and pupae were collected from banded trees near Glassboro in southern New Jersey at intervals thruout most of the summer. These were transferred to the insectary at New Brunswick. Emerging adults were placed in small cages containing apple foliage and produced a steady supply of viable eggs. Toward the latter part of August surplus eggs were placed in the ice box. These were used for about two weeks after fresh eggs had ceased to be available. The viability of the cold storage eggs was variable, but always high enough for purposes of making direct comparisons.

Preparation of Tank Mixed Nicotine Tannate. The Tannic Acid used was obtained direct from the manufacturers and was described as "Tannic Acid U.S.P. grade Fluffy," made by extracting "Chinese Galls" by the method described in the U.S. Dispensatory

Free nicotine was obtained from the Tobacco By-Products and Chemical Corporation.

The spray mixture was prepared by dissolving four parts of the tannin in 1600 parts of water and adding with stirring one part of free nicotine (= two parts of 50 per cent free nicotine).

Duration of Toxicity on Foliage. Two small apple trees were sprayed at New Brunswick with tank mixed Nicotine Tannate. At intervals after spraying two or more leaves were removed from each sprayed tree, and from a neighboring unsprayed tree of the same variety (Yellow Transparent). A portion of each leaf, excluding large veins, was placed, under side down, in a stender dish with five newly hatched codling moth larvae and the whole covered with a bell jar and kept at a high humidity for three days. At the end of this period the number of living larvae in each dish was counted. Under these conditions it was found that the insects would live and grow rapidly on unpoisoned foliage for at least two weeks, cannibalism being the only apparent cause of death. Most of the feeding was on the lower side of the leaves.

TABLE 1. SURVIVAL OF YOUNG CODLING MOTH LARVAE ON APPLE FOLIAGE SAMPLED AT DIFFERENT INTERVALS AFTER SPRAYING
FIVE LARVAE WERE PLACED ON EACH LEAF SAMPLE AND THE FIGURES IN THE TABLE SHOW THE NUMBER FOUND ALIVE AFTER THREE DAYS

Rainfall records inches	Day sampled	Control unsprayed	Av.	Sprayed Nicotine Tannate Tree No. 1	Av—1	Tree No. 2	Av—2	Av. 1+2 / 2	% Living Control	% Living Sprayed
.06	0	4 2 3 2	2.75	1 1	1	0 0	0	0.50	55	10
.01	1	0 3 2 4	2.25	0 0	0	0 0	0	0	45	0
	2	3 4 2 1	2.50	0 0	0	0 1	0.5	0.25	50	5
	3	2 2 2 4	2.50	0 0	0	3 0	1.50	0.75	50	15
.26										
	7	1 1 4 3	2.25	1 1	1	0 1	0.50	0.75	45	15
	8	4 3 5 3 2 4 3 4	3.50	0 1 2 2	1.25	1 0 0 0	0.25	0.75	70	15
.08										
	11	2 2 4 2 4 3 4 2	2.87	0 1 0 0	0.25	0 0 0 1	0.25	0.25	57	5
	12	2 2 3 3	2.50	0 0	0	0 0	0.00	0	50	0
	13	5 3 2	3.33	2 0	1.00	0 0	0	0.50	67	10
	15	5 3 2 2	3.00	0 0	0	0 0	0	0	60	0
3.12										
	20	5 4 5 3 5 3 3	4.00	0 4 1 2	1.75	0 0 3 3	1.50	1.62	80	32

All together 110 leaf samples and 550 insects were used.
It will be seen that the treated foliage tended to be decidedly unwholesome to codling moth larvae for at least 21 days.

Some data obtained in this way from trees sprayed July 24, 1931 is given in Table 1.

DURATION OF TOXICITY ON FRUIT. For this experiment a large King David apple tree at New Brunswick was used. It had received the regular schedule of sprays up to July 25 on which date it was sprayed with arsenate of lead and New Jersey dry mix. The fruit was practically free from codling moth injury.

TABLE 2. CODLING MOTH INJURY TO APPLES DIPPED IN ARSENATE OF LEAD COMPARED WITH APPLES DIPPED IN NICOTINE TANNATE
a = entries, b = living larvae

Sampled:— days after dipping		Control Apple No. 1 2 3	Control Average	Arsenate of Lead Apple No. 1 2 3	Arsenate of Lead Average	Nicotine Tannate Apple No. 1 2 3	Nicotine Tannate Average
0	a	6 4 3	4.35	11 4 9	8.00	0 0 2	0.67
	b	1 3 2	2.00	6 3 2	3.67	0 0 2	0.67
2	a	0 8 5	4.33	10 2 6	6.00	7 3 4	4.67
	b						
5	a	6 0 2	2.67	2 2 1	1.67	0 2 1	1.00
	b	1 0 0	0.33	0 0 0	0.00	0 0 0	0.00
8	a	9 7 8	8.00	2 2 8	4.00	9 1 2	4.00
	b	3 1 5	3.00	0 0 2	0.67	0 0 0	0.00
11	a	3 0 0	1.00	4 0 1	1.67	0 0 0	0.00
	b	0 0 0	0.00	2 0 0	0.67	0 0 0	0.00
15	a	12 2 4	6.00	6 1 8	5.00	0 5 2	2.33
	b	7 2 2	3.67	3 0 4	2.33	0 2 0	0.67
Grand averages							
Entries (a)			4.4		4.4		2
Living larvae(b)			1.8		1.5		0.27

Two mixtures were used, (1) the tank mix Nicotine Tannate already described and (2) arsenate of lead 3 parts + dry sweet skim milk 1 part to 600 parts of water. A number of apples were dipped in each spray mixture on August 29. This was accomplished by using a beaker filled with the mixture, stirring vigorously and immediately immersing the apple. The fruit was left on the tree and at intervals of several days three apples which had been dipped in each mixture and three untreated apples were removed from the tree. Each sample consisting of three apples was placed in a battery jar, 30 codling moth eggs added and a cloth cover placed on the jar. After the expiration of from 5 to 12 days the apples were removed and examined for entry and living larvae. Table 2 gives the results of these counts.

The numerical data in this table shows a wide variation due to the small number of apples in each sample and to the fact that cold storage

eggs of variable vitality had to be used in part. However, this is the only data we have at this time and its presentation appears to be justified because of the consistent superiority of Nicotine Tannate to arsenate of lead. The total rainfall for the period was 0.68 inches.

NICOTINE TANNATE AS AN OVICIDE. Eggs 0, 1, 2, 3 and 4 days old were sprayed with tank mixed Nicotine Tannate. Table 3 gives the observations.

TABLE 3. OVICIDAL ACTION OF NICOTINE TANNATE

Age of eggs Days	Nicotine Tannate		Control	
	Number of eggs	Per cent hatching	Number of eggs	Per cent hatching
0	13	92	22	91
1	22	95	14	57
2	20	60	6	100
3	23	8.7	45	98
4	12	8.3	15	100

It will be seen that Nicotine Tannate resembles nicotine sulphate in its ovicidal action. Three and four day eggs (which would have hatched on the 5th day) are killed. Young eggs are not killed.

DISCUSSION. In its action against codling moth larvae, Nicotine Tannate exhibits the characteristics of a contact insecticide plus a stomach poison. As a contact poison it kills relatively mature eggs and crawling larvae. As a stomach poison it is shown to persist on foliage in quantities toxic to young codling moth larvae for at least 21 days There are indications that its toxicity and effectiveness as a stomach poison are greater than those of arsenate of lead.

It will be seen, therefore, that this material is of more interest than was at first imagined. Its use not only eliminates the problem of arsenical residue, but promises to result in better control of codling moth. As used at present in New Jersey its cost is not materially greater than that of arsenate of lead, provided the cost of washing is taken into consideration. New Jersey growers have been paying about forty cents per pound for Tannic Acid and using one part of nicotine to 1600 parts of water. Experiments are now under way which may result in marked reduction of the cost of Tannic Acid. At the same time it seems altogether possiible that the dosage of Nicotine Tannate or the frequency of application, may be subject to material reduction. In other words, Nicotine Tannate may prove to produce more clean fruit per spray dollar than Arsenate of Lead.

PREPARATION OF TANK MIXED NICOTINE TANNATE. *Tannic Acid.* This should be made from Chinese galls. No other satisfactory source is known to the writer. Some tannins from other plants have been

tried but have in no case been satisfactory. Severe foliage injury has resulted from the use of inferior tannins.

Nicotine. Free Nicotine (Black Leaf 50) must be used.

Mixing. Fill the tank about two-thirds full and start the agitator. Add for each 100 gallons two pounds of Tannic Acid. This should dissolve quickly. Finally add one pint of 50 per cent free nicotine for each two pounds of Tannic Acid. Fill up the tank and apply the spray.

Compatibility. Nicotine Tannate can be used with pure sulphur. It cannot be mixed with soap, lime sulphur, calcium caseinate or other alkaline or acid substance. Its compatibility with dried milk or other protein or organic base is open to question.

LITERATURE CITED

1. HEADLEE, T. J., GINSBURG, J. M., and FILMER, R. S. 1930. Some Substitutes for Arsenic in Control of Codling Moth. Journal of Economic Entomology, Vol. 23, No. 1, p. 45.
2. FILMER, ROBERT S. 1931. Comparative Performance of Nicotine Tannate and Lead Arsenate Against the Codling Moth. Journal of Economic Entomology, Vol. 24, No. 1, p. 278.

STUDIES OF CODLING MOTH FLIGHT[1]

By HARLAN N. WORTHLEY, *The Pennsylvania State College*

ABSTRACT

Distance and direction of dispersal were studied through bait-pail catches of marked moths (*Carpocapsa pomonella*). Data relative to weather conditions affecting the beginning, peak, and end of the daily flight period were gathered by hourly evening examinations of bait pails and weather instruments. Most moths were captured within five-hundred feet of the liberation point, and showed a slight tendency to seek shelter from prevailing winds. Evening flight began before sunset, reached its peak the hour following, and decreased with complete darkness. Flight occurred below sixty degrees Fahr., and increased with rising temperature. It was prolonged by moonlight and stopped by rain. The data indicate the possible effect of other factors.

The prospective use of control measures, such as lights and baits against the adult codling moth should be based on a detailed knowledge of conditions governing the flight of this species. It was with the thought of adding to the existing information on this subject that the present study was made at State College during the period of spring brood flight in 1931. Particular attention was given to the distance and

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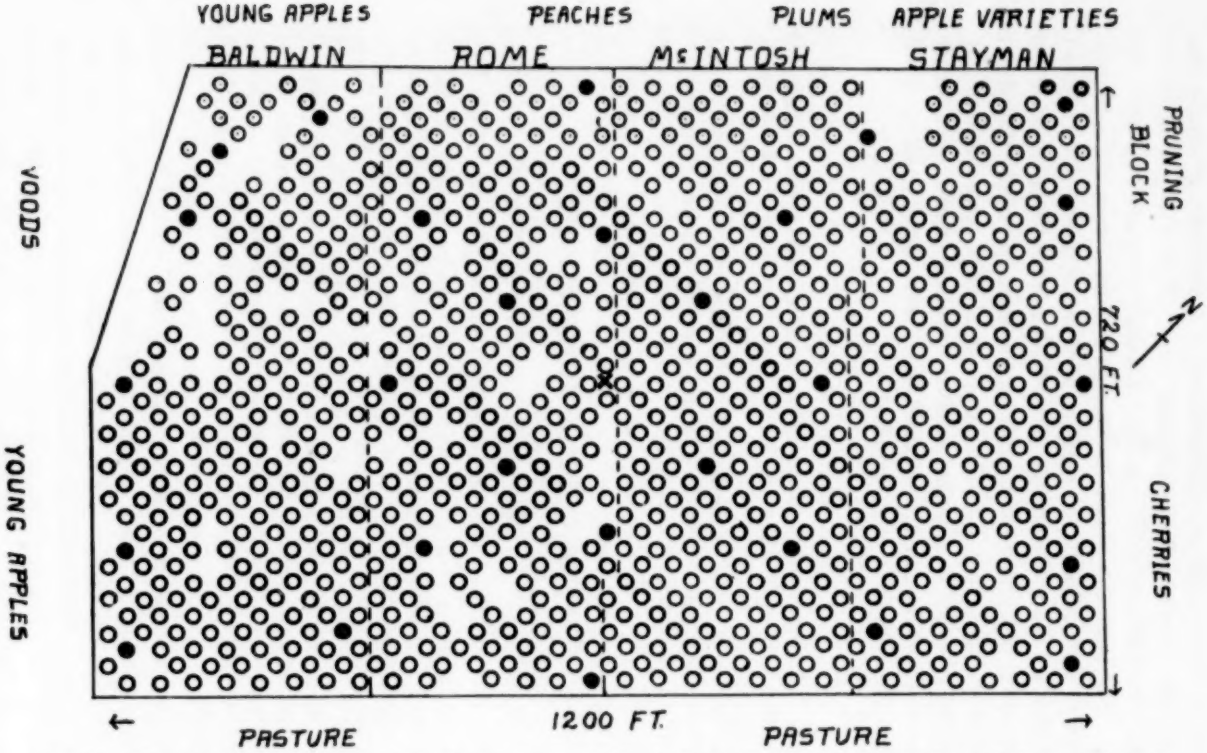

FIG. 33.—The "Student Orchard" of the Department of Horticulture, The Pennsylvania State College. Planted 1917. A low ridge extends from the woods to the "Pruning Block," being highest near the upper end of the McIntosh section. The most pronounced slope is toward the south and south-east. Solid circles represent trees pailed for the moth flight studies. The natural population of codling moths in this orchard is very low. Moths were released at "X."

direction of spread and to the stimulating or retarding effect of weather conditions on the flight activity of the moths.

METHODS. Distance and direction of spread were determined by the recovery in bait-pails of marked codling moths liberated at the center of a twenty-acre block of apple trees. Conditions affecting moth activity were studied in a block of one hundred old apple trees located adjacent to the college campus, and known as the "Hungarian Orchard." Here the records of hourly bait-pail catches were supplemented by weather observations made at each examination of the pails.

Moths were gathered in individual vials from emergence cages of various types used in studies of seasonal occurrence. A saturated solution of safranin in seventy per cent alcohol was applied to the wings by means of a fine camels hair brush. Many moths were stunned by the staining treatment, particularly if the head or thorax received the solution. In the first attempts a few moths were killed, but with practise a high percentage of recoveries was obtained. The marked moths were transferred to screen-wire cages in the insectary, where they were fed sugar-syrup on sponges until liberated one to three days later.

Liberations were made during the middle of the day. The cages were placed on the ground in a clear space between trees, opened, and tapped to induce the moths to take wing. Healthy moths invariably flew upward and darted into the foliage of nearby trees. All moths unable to reach the trees were recaptured and killed, and are not included in the records.

The twenty-eight bait pails used were gallon size (No. 10) preserving cans coated inside and out with aluminum paint, and provided with long hooked bails of galvanized wire. The bait consisted of one part "Brer Rabbit" brand cooking molasses in ten parts of water, three quarts to each pail. The pails were filled and hung on convenient branches in the top center of the selected trees two days before the first libertation of moths, in order that fermentation might be well under way. A plan of the orchard used, showing the location of pails, is given in Figure 33.

In the "Hungarian Orchard" four bait pails were employed. These were located in the tops of trees near the four sides of the block, and were raised and lowered by means of cord and pulleys. At each collection of moths, weather records were made. These consisted of sling psychrometer readings of dry and wet bulb temperatures, atmospheric pressure as registered by an anaeroid barometer corrected for elevation (1200 ft.), and notes on air movement, character of the sky, and precipitation.

BEHAVIOR OF MARKED MOTHS. With few exceptions the pails in the "Student Orchard" were examined daily from June 1 to June 23. Males and females, marked and unmarked moths were recorded separately. In all, four hundred three moths were captured. One hundred sixty-one, or forty per cent of these were found to be marked. Only the marked moths are discussed here. The record of liberation and recovery is given in Table 1.

TABLE 1. LIBERATION AND RECOVERY OF MARKED CODLING MOTHS STATE COLLEGE, PA., 1931

Date	Moths liberated			Moths recovered		
	♂	♀	Total	♂	♀	Total
5/29	30	10	40	–	–	–
6/1	114	133	247	3	6	9
6/2	—	—	—	1	0	1
6/3	—	—	—	8	7	15
6/4	67	96	163	1	7	8
6/5	—	—	—	4	2	6
6/6	73	66	139	0	2	2
6/9	133	136	269	0	3	3
6/10	—	—	—	1	1	2
6/11	—	—	—	13	3	16
6/12	103	93	196	4	7	11
6/13	68	82	150	3	3	6
6/15	—	—	—	2	11	13
6/17	88	107	195	1	0	1
6/18	—	—	—	15	8	23
6/19	—	—	—	15	17	32
6/20	16	14	30	4	7	11
6/22	—	—	—	0	1	1
6/23	—	—	—	1	0	1
Total	692	737	1,429	76	85	161
Percent recovered				11.0	11.5	11.3

The forty moths released on May 29 were allowed three nights of flight before the pails were examined. On June 1 nine of these moths, or twenty-two per cent of the total, were found in the pails. One was taken at a distance of six hundred seventy feet from the point of liberation, marked X in Figure 33.

Only about eleven per cent of the moths were captured. It may be supposed that many found their way to the younger trees to the south, or to the Variety and Pruning blocks to the north. However, the figures given in Table 3 fail to indicate any significant drift in these directions. In addition, Yothers[2] obtained a marked reduction of codling moth injury in a pailed block of only forty-two trees, and later[3] reported no greater catch of moths in pails having forty unpailed trees to draw from than in those drawing from twenty-six trees. These records indicate a

[2]J. Ec. Ent. 20, 573, 1927. [3]J. Ec. Ent. 23, 929, 1930.

tendency of the codling moth to remain near the point of emergence within the orchard.

The twenty-eight pails caught eleven per cent of the moths. Since the orchard contains in the neighborhood of one thousand trees the possibility is suggested that the pailing of twenty-five per cent of the trees would have sufficed to trap nearly all of the moths.

The extent to which the captured moths had spread away from the point of liberation is shown in Table 2.

TABLE 2. RECOVERY OF MARKED CODLING MOTHS AT VARIOUS DISTANCES FROM POINT OF LIBERATION

Moths recovered	♂	♀	Total	Per cent
Under 200 feet	40	43	83	51.5
200 to 500 feet	31	35	66	41.0
Over 500 feet	5	7	12	7.5
Totals	76	85	161	—

Five moths were captured at the maximum distance of six hundred seventy feet. More than ninety per cent of the moths recovered were less than five hundred feet from the center of the orchard, and over fifty per cent within two hundred feet. Thus the concentration decreased with increasing distance from the point of liberation. The figures indicate no difference in flight habits of the sexes.

TABLE 3. DIRECTION AND DISPERSAL OF MARKED MOTHS

Quarter of orchard	No. of pails	Moths caught ♂	♀	Total	Moths per pail
North	9	30	29	59	6.5
East	9	31	32	63	7.0
South	9	26	37	63	7.0
West	9	24	27	51	5.6

During the period of observation the maximum wind velocity from 8:00 to 12:00 P.M. on any day was ten miles per hour, and the minimum one mile per hour, as recorded by the anemometer at the college weather station. For the twenty-five day period the evening air movement averaged about four miles per hour, and at one time or another came from all points of the compass. Air drift from the west and north predominated on eighteen of the twenty-five evenings.

In order to discover any tendency on the part of the moths to seek a particular section of the orchard, the block has been divided into quarters for the purpose of examination. In Table 3 the pails on border lines have been included in both quarters touched, and in consequence totals will not check with those given in Tables 1 and 2.

No marked tendency to seek one section of the orchard can be seen. The slight concentration to the east and south may possibly represent

TABLE 4. HOURLY BAIT PAIL CATCHES OF CODLING MOTHS COMPARED WITH WEATHER CONDITIONS, STATE COLLEGE, PA., 1931

Date	Hour	Moth catch ♂	♀	Tot.	Temp. °F	Rel. Hum. pct.	Bar.	Air movement	Sky
5/28	7:30P	0	0	0	79	40	30	SW—very slight	Clear above—sun sinking in clouds
	8:30P	10	7	17	77	43	30	SW—slight and fitful	Moonlight—rather hazy
	9:30P	8	6	14	74	50	30	SW—slight and fitful	Moonlight—rather hazy
	10:30P	3	2	5	73	51	30	SW—somewhat stronger	Moonlight—rather hazy
	11:30P	3	0	3	70	55	30	S—slight—fitful	Moonlight—rather hazy
5/29	12:30A	2	1	3	65	70	30	N—very slight	Moonlight—ground haze—dew forming on grass
	1:30A	0	0	0	65	70	30	N—very slight	Moonlight waning
After	1:30A	0	1	1					
5/31	7:30P	1	0	1	62	79	29.6	NW—light—fitful	Sun setting—partly cloudy
	8:30P	2	1	3	60	83	29.6	N—very slight	Dim western light—mostly cloudy
	9:30P	0	0	0	60	83	29.6	N—slight	Cloudy—gentle rain began 9:25
After	9:30P	0	0	0					
6/3	7:30P	1	1	2	67	58	29.9	W—gentle—just stirs leaves	Clear above—sun sinking in clouds
	8:30P	1	4	5	63	67	29.9	W—gentle—just stirs leaves	Clear—western light nearly gone
	9:30P	2	1	3	65	61	29.9	W—slight	Clear—dark
	10:30P	1	0	1	60	73	29.9	NW—slight	Clear—dark
After	10:30P	1	1	2					
6/10	7:30P	0	0	0	65	70	29.8	N—moderate	Sun setting—partly cloudy
	8:30P	2	4	6	63	71	29.8	N—slight	Nearly dark—partly cloudy
	9:30P	0	0	0	62	79	29.8	N—very slight	Dark—partly cloudy
	10:30P	1	0	1	62	79	29.8	N—very slight	Dark—partly cloudy
	11:30P	0	0	0	60	78	29.8	N—very slight	Dark—partly cloudy
After	11:30P	0	0	0					

the result of drifting with air currents. These sections are slightly lower than the rest, and would offer some protection from north and west winds.

FLIGHT and WEATHER. In the "Hungarian Orchard" four series of observations were made, the results of which are given in detail in Table 4.

Examination of Table 4 shows that on all four evenings some catches were made before sunset, that they increased during the following hour, and decreased as complete darkness approached. Moonlight seemed to prolong the flight period, which ended as the moonlight waned, even though the temperature remained well above sixty degrees Fahr. It will be noted that on one evening two moths entered the pails after the temperature had dropped below sixty degrees.

Some additional facts become more apparent when the data are arranged as in Table 5. Moth flight increased with rise in temperature and fall in atmospheric moisture, these two phenomena being normally associated. It was highest at higher barometric pressures. It appeared to be favored by light air currents from the south and west over those from the north. Cloudiness was associated with low moth catch, and a light precipitation stopped flight entirely.

TABLE 5. MOTH CATCH AND WEATHER CONDITIONS

Date	Moth catch	Ave. temp.	Hourly humid	Bar. press.	Prevail. wind.	Light and precip.
5/28	42	71.8	54.1	30	SW—very slight	Moonlight
6/3	13	63.7	64.7	29.9	SW—gentle	Clear—dark
6/10	7	62.4	75.4	29.8	N—very slight	Partly cloudy dark
5/31	4	60.6	81.6	29.6	N—very slight	Cloudy—light rain

SUMMARY. Bait pail catches of marked codling moths indicated that the sexes have similar flight habits, that they tend to remain within five hundred feet of the point of emergence, but that they seek areas sheltered from prevailing night winds. In a small series of hourly evening observations, flight began before sunset, increased during the next hour, and decreased with complete darkness. The flight period appeared to be prolonged by moonlight. Slight air currents did not inhibit flight, those from the south and west seeming more favorable than those from the north. Flight activity occurred below sixty degrees Fahr., increased with rising temperature and the attendant fall in humidity, and was greatest above seventy degrees. It seemed to be favored by high barometric pressure. Cloudy weather retarded moth activity, and light rain-fall stopped it entirely.

TESTS AGAINST THE OVERWINTERING STAGE OF THE CODLING MOTH

By ERNEST N. CORY and P. D. SANDERS,[1] *University of Maryland, College Park, Maryland*

ABSTRACT

Tests of twenty-six combinations, with and without paradichlorobenzene, against the hibernacula of the codling moth (*Carpocapsa pomonella*) in two-inch bands showed that the tar washes and the pine oils at the higher concentrations were quite effective under the conditions of the test. Chemically treated codling moth bands show much promise.

This paper reports the results of one year's work devoted to the development of means to reduce the overwintering population of codling moth. This was done with the expectation that control of the first brood would be simplified if a satisfactory method could be developed.

Observations in Maryland have shown almost without exception that codling moth infestation is likely to be more severe in the immediate neighborhood of packing sheds than elsewhere in the orchard. This is due to the fact that the worms that spin up in the packing sheds are able to complete their development without being subjected to the same vicissitudes that beset worms that spin up in the orchard. Birds destroy a large percentage of the worms that spin up on the trees. Anyone who has attempted to find codling moth larvae in the spring on trees will bear witness to their scarcity at that time. In the packing shed, however, birds seldom are a factor and under Maryland conditions, since screening of packing sheds is impracticable, there is a constant influx of moths into the trees immediately surrounding the packing sheds over a long period. Emergence in 1931 began two weeks after the orchard emergence as shown in the chart.

Also, since it is impracticable to screen Maryland packing sheds, obviously some method should be developed by which the larvae which spin up there can be killed. The winter mortality of worms held in a screen wire cage in an orchard at Easton in 1930–31 was 2.6%, based on 2,358 worms. Mortality inside packing house in screen wire cage was 3.18% based on 2,519 worms. This would indicate that a large percentage of the worms that spin up inside the packing house were available to infest the fruit near the packing shed. The picture of the cocoons on a glove that was left by a workman over winter in the angle between one of the roof supports and a brace serves to show how numerous worms may be in packing sheds.

[1]Resigned June 1, 1931, to enter Bureau of Entomology.

CONTROL EXPERIMENTS ON HIBERNACULA. In order to determine the effectiveness of various dormant sprays in killing worms within hibernacula, twenty-six combinations were used upon worms spun up within two inch pasteboard bands. These were checked against lime sulfur and three lots to which only water was applied.

Two-inch corrugated pasteboard bands were placed around heavily infested apple trees on August 15 and removed and rolled up on October 23. These bands were kept in mouse-proof screen cages outside until the treatments were made in the spring of 1931. A total of 23,187 larvae were used in the work.

At the time of the treatment the bands were dipped in the solutions and placed separately in screen wire cages, exposed outdoors on a rack. The daily emergence of moths was recorded. The bands were finally stripped down and dead worms and pupae recorded to get the final results. The method cannot be expected to represent the kill that should be expected from orchard or packing house treatment, but seems well adapted to determine the materials that will penetrate the hibernaculum and serves as an indication of the materials used, that should be tested further under field conditions.

The results of this series are shown in the tables that follow. The materials have been grouped under the headings of tar washes, pine oils, and soluble and emulsified oils. The lime sulfur treatment has been grouped with the checks. The lime sulfur gave practically the same percentage of mortality as the three checks that were treated with water alone. The addition of paradichlorobenzene to the oil emulsions and soluble oils did not give any significant increase in the kill, but when added to the tar washes and the pine oils apparently increased the effectiveness of the original material, in most cases to an extent that would warrant the inclusion of the material in any spraying operations directed against the overwintering larvae.

TABLE 1. TESTS AGAINST OVERWINTERING LARVAE INSIDE THEIR HIBERNACULA

Materials used	Date Treated	Date Examined	Moths emerged	Dead Larvae	Dead Pupae	Dead Total	Per cent dead
Barko, (1–15).....	Apr. 17	June 27	109	10	24	143	23.77
Barko plus P.D.B., (1–15).....	Apr. 17	June 29	13	41	2	56	76.77
Barko plus P.D.B., (1–7½).....	Apr. 18	June 29	6	56	0	62	91.95
L. A. Tar Wash, (1–15).....	Apr. 18	June 29	39	11	45	95	58.94
L. A. Tar Wash plus P.D.B., (1–15)....	Apr. 18	June 29	31	8	11	50	38.00
L. A. Tar Wash plus P.D.B., (1–7½)...	Apr. 18	June 29	103	9	70	182	43.40
Solignum, (1–15)....	Apr. 20	July 2	179	6	13	198	9.59

TABLE 1. CONTINUED

Materials used	Date Treated	Date Examined	Moths emerged	Dead Larvae	Dead Pupae	Dead Total	Per cent dead
Solignum plus P.D.B., (1–15)	Apr. 20	July 2	85	4	28	117	27.36
Pinetrex, (1–15)	Apr. 18	June 29	51	1	6	58	10.71
Pinetrex plus P.D.B., (1–15)	Apr. 18	June 29	351	38	60	449	21.82
Pinetrex plus P.D.B., (1–7½)	Apr. 18	June 29	334	24	20	378	11.64
Pineol Soluble, (1–15)	Apr. 20	June 29	134	10	38	182	26.37
Pineol Soluble plus P.D.B., (1–15)	Apr. 20	June 29	140	67	37	244	42.62
Pineol Soluble plus P.D.B., (1–7½)	Apr. 20	June 29	6	39	3	48	87.50
Pineol Soluble	May 9	July 2	2	555	40	597	99.66
Pineol Soluble, (1–2)	May 9	July 2	39	520	53	612	93.62
Sunoco, (1–20)	Apr. 17	June 27	50	3	2	55	9.09
Sunoco plus P.D.B., (1–20)	Apr. 17	June 27	83	6	11	100	17.00
Sunoco plus P.D.B., (1–10)	Apr. 17	June 27	59	14	12	85	30.58
Kleenup, (1–20)	Apr. 17	June 27	30	0	1	31	——
Kleenup plus P.D.B., (1–20)	Apr. 17	June 27	58	1	12	71	18.30
Kleenup plus P.D.B., (1–10)	Apr. 17	June 27	35	27	2	64	43.75
Kleenup plus P.D.B. and 10% C CL_4 (1–20)	Apr. 17	June 27	176	6	14	196	10.20
Scalecide, (1–15)	Apr. 17	June 27	44	33	13	90	51.11
Scalecide plus P.D.B., (1–15)	Apr. 17	June 27	120	17	28	165	27.27
Scaleside, (1–5)	May 9	June 27	66	117	55	238	72.26
Check (water)	Apr. 20	June 27	125	7	9	141	11.34
Concentrated Lime Sulfur, (1–8)	Apr. 20	June 27	107	3	11	121	11.57
Check (water)	Apr. 17	June 27	54	0	6	60	10.00
Check (water)	Apr. 20	July 12	511	16	45	572	11.93

The solubility of paradichlorobenzene in a wide range of insecticides has been investigated by a graduate student, Mr. J. B. Gahan, in laboratory tests and has formed the basis for an unpublished thesis.

TABLE 2. SOLUBILITY OF PARADICHLOROBENZENE IN THE VARIOUS OILS USED IN THE EXPERIMENTS

Kind of Oil	cc. of Oil	Grams of PDB
Barko	505	404
Pineol Soluble	505	353
Scalecide	505	303
Pinetrex	505	202
Kleen-up	505	152
Sunoco	505	101
Long Ashton Tar Wash	505	101
Solignum	505	101

CHEMICALLY TREATED BANDS. The Cod-o-Cide bands were placed on the trees on July 8; the others, bands home treated with beta naphthol and beta naphthol with aluminium stearate[2], as well as the checks, on July 19. Records were made every two weeks on pupal skins exuding from bands until October 23 when bands were removed and placed in cages (mouse proof). When the bands were removed in the fall the worms that clung to the tree trunks were collected and the dead ones counted. The live ones were placed on the bands from which they came, to re-spin. Spring emergence records were made. The bands were later stripped down and the dead larvae and pupae recorded.

TABLE 3. CHEMICALLY TREATED BANDS

Plot No.	Kind of band used	No. trees	Emergence	Dead	Total	Per cent dead
I	Cod-o-Cide.....	10	1	3319	3320	99.96
II	Siegler Gov. Forumla.....	10	1	2638	2639	99.96
III	Siegler Gov. Formula plus Aluminum Stearate.....	10	0	2605	2605	100.00
IV	Check (plain corrugated pasteboard bands).....	10	1315	146	1457	10.02

In these tests there was no apparent injury to the tree. Possibly the greater catch in the treated series may be accounted for in part by the greater length of the bands. The lengths were as follows: Cod-o-Cide 42″, Plot II 44″, Plot III 44″, Check 32″.

The check bands were long enough to lap over several inches, and, since the trees were approximately the same size, the longer bands gave a considerably greater lap.

STUDIES ON CONTROL OF THE APPLE CURCULIO IN THE CHAMPLAIN VALLEY

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ABSTRACT

Apple curculio ((*Tachypterellus quadrigibbus*) injury recently appeared to a serious extent in a few eastern New York apple orchards. Life history and control studies were made. In experimental plots partial control was secured by the use of properly timed heavy sprays of lead arsenate. The addition of excess lime and fish oil apparently increased the effectiveness of the arsenical treatments.

Injury by the apple curculio, *Tachypterellus quadrigibbus* Say, to apple crops in the Champlain Valley of New York was first noted by A. B.

[2]Prepared and furnished by E. H. Siegler, Bureau of Entomology.

Burrell in 1927. At that time a few orchards in the vicinity of Crown Point showed light infestations. Since 1927 fruit in several orchards in Clinton, Essex, and Washington counties has been injured. In the past two years apple curculio infestations have been found in localized areas at various points over an area about 150 miles long between the towns of Middle Granville, N. Y. and Mooers, N. Y.

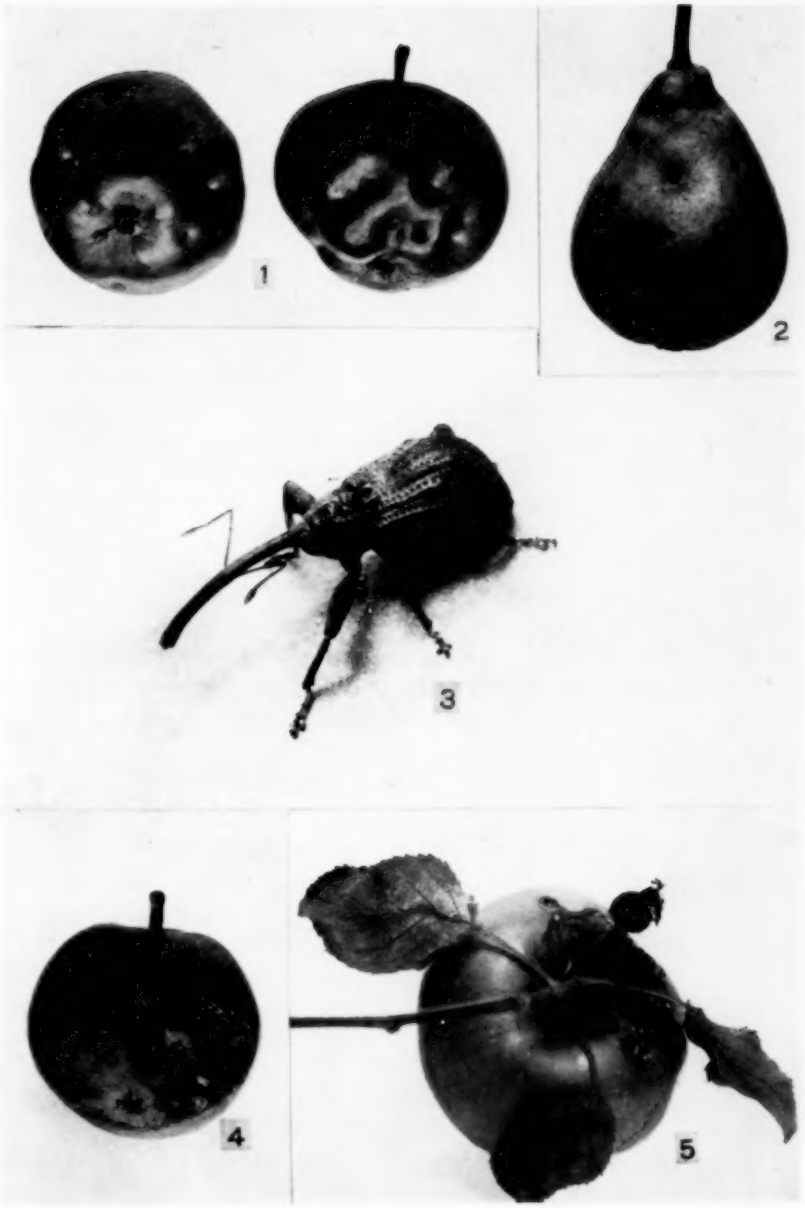
It was not until 1930 that injury became sufficiently severe to alarm growers. In 1930 and 1931 three instances of heavy losses due to attacks of this beetle were discovered. One grower estimates his losses at $4,500 to $5,000 in an eight acre block.

Host Plants. Apple curculio injury has been observed in New York State on apple, pear, plum, cherry, hawthorn, and wild crab. This same list is given by Petch (4). No oviposition of this species in plums and cherries has been observed, and it is believed these two fruits play no important role in the life history of the insect. In the Champlain Valley during 1931 one adult beetle was reared from 200 very small injured pears which dropped to the ground in late June and early July. Apparently the insect does not breed in pears to any great extent, although severe injury may result to the crop by early spring feeding. (Pl. 19, Fig. 2).

The hawthorn as reported by other investigators, appears to be very satisfactory for the development of the apple curculio.

Varietal Susceptibility. In the Champlain Valley no variety of apple appearing in apple curculio infested orchards has been entirely free from attacks by this pest. However, there appears to be a difference in degree of injury. Probably the varieties most severely injured are Tolman Sweet, Ben Davis, Winter Banana, and Northern Spy. Those least injured appear to be McIntosh and Fameuse. Among other varieties found infested are the following: Wealthy, Maiden Blush, Wagner, Delicious, Golden Russett, Wolf River, Northwestern Greening, Stayman Winesap, and Cortland.

Nature of Injury. Injury by the apple curculio results from adult feeding and oviposition punctures. The first evidences of injury are tiny holes through the skin of the fruit when it is about one-quarter inch in diameter. After these punctures are made, cavities are formed by the beetle feeding just beneath the skin of the apple. These punctures are made for feeding or oviposition and become more noticeable as the fruit grows. Usually a funnel shaped depression with the original puncture at the bottom is formed as the apple grows. The fruit becomes badly misshapen and gnarly (Pl. 19, Fig. 1). There are some varieties, notably the Ben Davis, in which a callus is formed instead of the usual



APPLE CURCULIO

1, Early injury on Tolman Sweets; 2, Early injury on pear; 3, Adult beetle; 4, Late injury on McIntosh; 5, Emergence hole in mummified Tolman Sweet with late injury on growing apple; both on the same fruit spur.

depression. Oviposition punctures can be distinguished from feeding punctures since they are usually closed with a tiny pellet of excrement.

Feeding by the new generation beetles comes at a time when the fruit has completed rapid growth. Cavities are often made close together with the result that the skin collapses and turns brown; blackened spots one-fourth to one inch in diameter are thus produced (Pl. 19, Figs. 4 and 5). Fulton (5) gives a very clear account of the types of injury.

Life History. The general life history, seasonal habits, and injury of this species have been carefully worked out by Gillette (1), Crandall (2), Brooks (3), Petch (4), Fulton (5) and others. For the most part these findings apply to the species in the Champlain Valley region.

By use of a cheesecloth cage placed over an infested area it was found that beetles commenced to move about on May 6. They were collected regularly from the side walls and top of the cage from this date until June 1, after which date no beetles were recovered.

Overwintering adults were first obtained from trees by jarring on May 14. On May 22 beetles were seen feeding on young apples. At this later date about 40 per cent of the petals had fallen from Wagner blossoms and fewer than that from Winter Banana and McIntosh.

Egg laying began during the last few days in May. Most of the eggs were deposited in the fruits while they were less than one-half inch in diameter. The fruits were so small that the majority of egg cavities extended into the seed proper and the eggs rested within the ovule. Rarely was more than one egg deposited in a single fruit. Oviposition extended over a period of about 45 days.

Adults began emerging from fruit July 13 at Willsboro and July 17 at Crown Point. The peak of emergence occurred within a few days after emergence began, as may be seen in Table 1.

Probably the majority of new generation curculios come from the June drops. This, however, is not always the case. A considerable number of the beetles emerge from small apples which cease growing, become mummified and cling to the fruit spurs (Pl. 19, Fig. 5). This is true especially of Tolman Sweet and Northern Spy varieties. Furthermore many cases have been noted in which the beetles continue their development in growing fruits. At picking time (September 4 to 18) larval, pupal, and adult stages of the apple curculio were found alive within mature Wealthy and McIntosh apples, and a few recently formed emergence holes were observed.

Hibernation Quarters. Since all orchards infested with apple curculio in the Champlain Valley are in sod, it was under these conditions that hibernation was studied. A wooden frame 13 feet square and

3 feet high, covered with cheesecloth, was placed under a tree, known to have had a severe infestation in 1930. The cage was erected early in the spring of 1931. From this area seventy-nine beetles emerged between May 6 and May 29. This result, together with the fact that about 80 beetles were collected from debris and matted grass under trees as late as October 20 during 1930 indicates that many of the beetles spend the winter under the trees which were infested the previous summer.

TABLE 1. NEW GENERATION BEETLES. CAGE EMERGENCE RECORD, CROWN POINT, N. Y., 1931

Approximate quantity of "June Drops"	Dates of collection	Number of beetles
10–12 bushels.	July 14	0
	July 15	0
	July 16	0
	July 17[1]	–
	July 21	822
	July 22	274
	July 23	190
	July 26	294
	July 28	168
	August 1	49
	August 4	94
	August 6	56
	August 11	29
	August 14	59
	August 19	22
	August 24	2
	August 26	0
	August 30	0
Total		2059

[1]First beetles appeared in cage. These, and those emerging July 18, 19, and 20 not removed until July 21.

CONTROL EXPERIMENTS. In regard to control measures, the concensus of opinion appears to be that arsenical sprays are rather ineffectual against the beetle. Many investigators advocate destruction of infested June drops as the most satisfactory control measure. Fulton (5) strongly recommends the use of hogs for cleaning up these drops. In the F. L. Porter orchard near Crown Point all fallen fruits were collected by hand in an eight acre block of severely infested Tolman Sweet and Spy trees. While this method proved tedious and expensive, it undoubtedly reduced the amount of feeding by new generation beetles. However, at harvest, there was considerable evidence of injury by new beetles. The partial failure of control in this planting may have been due largely to adults which had emerged from apples clinging to the trees.

A review of literature indicates that not many extensive tests have been made on the control of this species by use of poisonous sprays. If

control can be obtained by spraying this method would be better adapted to orchard practices than the other methods recommended.

TABLE 2. APPLE CURCULIO SPRAYING EXPERIMENT, WILLSBORO, N. Y., 1931

No. plat	Spray formula (Water added in each case to make 100 gallons)	Number beetles jarred from one tree May 28–June 25	Variety	Total fruit each tree	Early injury No. apples	Early injury Per cent
I	Lead arsenate 3 lbs. Lime sulfur 2½ gals Fish oil 1 qt.	35	Wagner Winter Banana	405 268	38 47	9.4 17.5
II	Lead arsenate 3 lbs. Lime-sulfur 2½ gals.	117	Wagner Winter Banana	681 1000	111 553	16.3 55.3
III	Lead arsenate 6 lbs. Lime-sulfur 2½ gals.	39	Wagner Winter Banana	554 1036	55 100	9.9 9.6
IV	Lead arsenate 6 lbs. Lime-sulfur 2½ gals. Hydrated lime 25 lbs. Fish oil 1 qt.	8	Wagner Winter Banana	524 1334	9 86	1.7 6.4
V	Lead arsenate 3 lbs. Lime-sulfur 2½ gals. Hydrated lime 25 lbs.	37	Wagner Winter Banana	624 1675	98 422	15.7 25.2
VI	Complete check . . . . . No spray	98	Wagner Winter Banana	843 2075	145 898	17.2 43.3

All plats sprayed May 9, May 25, June 1, and June 11.

SPRAY EXPERIMENTS. At the Adirondack Fruit Farms near Willsboro, N. Y., a block of 90 trees was divided into six plots each containing trees of the varieties Winter Banana, Wagner, and McIntosh. During 1930 there was no crop on the Wagner and McIntosh trees, while in 1931 both varieties bore fair crops. In both 1930 and 1931 Winter Banana trees bore about 50 per cent of a crop. The area selected for the experiment seemed to be uniformly infested with apple curculios in 1930. The spraying of the plots was timed to meet the spring and early summer feeding of the overwintering beetles. Table 2 summarizes the treatments each plot received and the results obtained.

SPRAY TIMING EXPERIMENTS. If benefits can be realized by spraying it is desirable to know when applications should be applied to attain maximum efficiency.

Another portion of the Adirondack Fruit Farms was chosen for a spray timing test. This area consisted of a square block of 25 trees. There were five rows, each row consisting of three Wealthy and two McIntosh

trees. During 1930 the McIntosh bore no apples while in 1931 they had a heavy crop. Some of the Wealthy trees bore each year. During 1930 the rows appeared to be about uniformly infested with apple curculios. Table 3 summarizes the treatments each row received and results obtained.

TABLE 3. APPLE CURCULIO SPRAY TIMING EXPERIMENT, WILLSBORO, N. Y., 1931

No. plat	Date sprayed	Spray formula (Water added in each case to make 100 gallons)	Variety	Total fruit each row	Early injury No. apples	Early injury Per cent
A	May 9, 25 June 1, 11	Lead arsenate 3 lbs. Lime-sulfur 2½ gals. Fish oil 1 qt.	Wealthy McIntosh	1155 1152	76 145	6.6 12.6
B	May 9 May 25 June 1 June 11	Lime-sulfur 2½ gals. Lead arsenate 3 lbs. Lime-sulfur 2½ gals. Fish oil 1 qt.	Wealthy McIntosh	270 1485	60 461	22.2 31.0
C	May 9, 25 June 1 June 11	Lime-sulfur 2½ gals. Lead arsenate 3 lbs. Lime-sulfur 2½ gals. Fish oil 1 qt.	Wealthy McIntosh	777 967	279 280	35.9 28.9
D	May 9, 25 June 1 June 11	Lime-sulfur 2½ gals. Lead arsenate 3 lbs. Lime-sulfur 2½ gals. Fish oil 1 qt.	Wealthy McIntosh	742 1683	346 719	46.6 42.7
E	May 9, 25 June 1, 11	Lime-sulfur 2½ gals.	McIntosh	851	461	54.2
F	Not sprayed	Check	Wealthy	1386	925	66.7

In most cases where fish oil was used there resulted some spray injury to the foliage and a reduction of the amount of fruit which set. Further tests are necessary to determine the margin of safety in the use of fish oil.

EFFECT OF SPRAYS ON NEW GENERATION APPLE CURCULIOS. New generation beetles feed more freely on the apple in the late summer than they do the following spring. In tests for the control of this late summer feeding, cryolite and lead arsenate appeared to offer most promise.

On August 5, a small Wealthy tree bearing about one barrel of apples was treated with a spray consisting of 6 pounds of cryolite in 100 gallons of water. This tree was then entirely enclosed by a cheesecloth cage. The surface under the tree and cage was completely covered with a large sheet. One hundred new generation apple curculios were released in the cage as soon as the spray had dried. Collections were made from time to time to remove the dead beetles on the sheet. The test

was discontinued September 3. Seventy-seven of one hundred beetles released in the cage were recovered. Of these, 74 were dead and 3 alive at the conclusion of the test. A careful examination of the total crop of 533 apples from the sprayed tree showed 12 with feeding. This number is very low considering the number of beetles which were introduced into the cage.

In another test with cryolite sprayed on a naturally infested tree not caged, eleven dead beetles were collected from a sheet placed under the tree.

Four naturally infested trees were sprayed with a mixture of 4 pounds of lead arsenate in 100 gallons of water. Sheets were placed under two of these sprayed trees. From one sheet 22 dead beetles were taken and from the other sheet 10 were collected.

Summary

Injury by the apple curculio in the Champlain Valley is increasing in importance. Losses are due to the injury caused by the feeding of both the overwintering and new generation beetles.

Overwintering adults emerged during May in 1931. The new generation beetles began emerging about the middle of July in this season.

According to tests in 1931, arsenical sprays applied during the period beetles were feeding and ovipositing in the spring, appear to give measurable control. Whether the considerable decrease in injury compared with checks may be attributed to killing the beetles, repelling them or both, is not clear at this stage of the investigation. Further tests on a larger scale are planned for 1932.

A spray formula consisting of 6 pounds of lead arsenate, 2½ gallons of lime sulfur, 25 pounds hydrated lime, 1 quart of fish oil, and water to make 100 gallons appeared to give the best control in 1931. The standard formula, consisting of 3 pounds of lead arsenate, 2½ gallons lime sulfur, and water to make 100 gallons, apparently gave little control.

Literature Cited

1. Gillette, C. P. The Apple Curculio. Iowa Agr. Exp. Sta. Bul. 11:492–494. 1890.
2. Crandall, Charles S. The Curculio and the Apple. Univ. of Ill. Agr. Exp. Sta. Bul. 98:467–560. 1905.
3. Brooks, F. E. Three Snout Beetles that Attack Apples. West Va. Agr. Exp. Sta. Bul. 126:105–124. 1910.
4. Petch, C. E. The Apple Curculio and its Control in Quebec. Canada Dept. of Agr. Ent. Branch Circ. 36:1–4, (Revised). 1926.
5. Fulton, B. B. The Apple Curculio and its Control by Hogs. Jour. Agr. Res. 6 (3): 249–261. 1928.

DISPERSAL OF THE APPLE MAGGOT

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ABSTRACT

This paper presents the results obtained and the technique developed in a study of apple maggot (*Rhagoletis pomonella*) dispersal. A total of 1,035 flies were marked and liberated at one release point during the course of the experiment. Of this number 123 individuals were subsequently recovered at distances varying from 38 to 156 yards from the liberation point.

Due in part to the recent import restrictions laid down by Great Britain in connection with the apple maggot, this insect is now regarded as the most important apple pest in Maine.

The question of apple maggot fly dispersal has long been a controversial one, certain investigators maintaining that the flies tend to remain in the immediate vicinity of the trees under which they emerge, while others believe that they move about freely from tree to tree and from orchard to orchard.

Many workers have reported difficulty in controlling this insect in plantings located near neglected trees. Several years ago, Severin (1916)[1] reported the failure of spraying under village conditions in Maine. More recently Bourne (1931) has stated that infestation from neglected trees, in many cases, is sufficient to offset the value of control measures practiced in commercial blocks in Massachusetts.

Under Maine conditions many commercial plantings are located near neglected apple trees. Counts which we have made this season clearly indicate that such neglected trees increase the problem of controlling the apple maggot. In one McIntosh and Wealthy orchard the Wealthy fruits in a border row were 30 per cent free from maggot injury, while samples near the middle of the block ran over 70 per cent clean. The border row was within 50 yards of a number of unsprayed apple trees. Another planting consisting entirely of Ben Davis trees yielded 28 per cent maggot free apples at one end. A number of neglected natural fruit trees was situated within 100 yards of this portion of the planting. The fruit at the other end of the block ran 86.7 per cent clean. From the standpoint of control a knowledge of the dispersal habits is therefore exceedingly important.

REVIEW OF DISPERSAL STUDIES BY OTHER WORKERS. *Results with the house fly.* Because of its importance as a disseminator of disease, the dispersal habits of the house fly have been the object of considerable

[1]Dates in parentheses refer to Literature Cited at Conclusion of paper.

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Marked and unmarked flies. Row 1, unmarked females; rows 2 and 3, aluminum marked males and females; row 4, gold marked males.

study. In one experiment Parker (1916) marked and released nearly 400,000 flies. By means of baited fly traps he subsequently recovered 1,056 individuals.

Results with fruit flies. Efforts to study the dispersal habits of the apple maggot and other fruit flies have been largely unsuccessful either because of inability to mark the flies satisfactorily, or in sufficient numbers, or because of inability to recover them in significant numbers. The absence of an apple maggot fly attrahent has prevented the use of traps as a means of recovery. Negative results in connection with apple maggot dispersal experiments are reported by O'Kane (1914), Brittain and Good (1917), and Porter (1928).

TECHNIQUE DEVELOPED IN MARKING THE FLIES. *Materials.* Preliminary experiments with colored chalk dust, various chemical dyes, indelible ink, and lacquers gave unsatisfactory results. Similarly, such practices as clipping marks in the wings or amputating a leg proved time consuming and undesirable. The use of gold and aluminum radiator gilding was finally suggested. The paint which was used in this experiment is known as Chi-Namel gold and aluminum manufactured by the Ohio Varnish Company of Cleveland, Ohio. The material comes in two parts, one consisting of dry gold or aluminum powder, and the second of a liquid mixing agent consisting chiefly of banana oil. The two materials are mixed together to form a fairly heavy paint. The resulting enamel dries quickly, is insoluble in water, adheres extremely well to the bodies of the flies, and does not seem to injure them.

Methods. The flies were quieted for the purpose of marking in two ways. The most satisfactory method was to subject them to a temperature of about 35 degrees F. for a few minutes. As soon as the flies became completely numbed they were spread out on a paper and marked. By means of a camels hair brush a small spot of enamel was placed on the thorax of each (Plate 20). A cold storage plant located near the release area furnished an opportunity for this work.

The second method was to etherize the flies in small vials. Two vials were kept in operation, one person marking the flies while a second etherized them and kept a supply ready. By this procedure two workers can readily mark 200 or more flies an hour. Longevity tests indicated that the cold method of treatment is preferable.

DESCRIPTION OF RELEASE AREA. The area selected for this experiment had been decided upon in 1930. It is typical of village conditions in that the trees are never sprayed. The site (Fig. 34) is quite level and is bordered on one side by a road upon which are a number of village homes. Old neglected apple trees of many varieties are located behind

these houses. The entire strip is between four and five hundred yards in length and about one hundred and fifty yards in width. In one direction two arbor vitae hedges extend back from the road and tend to form barriers which extend across the zone. These hedges are about 25 feet in

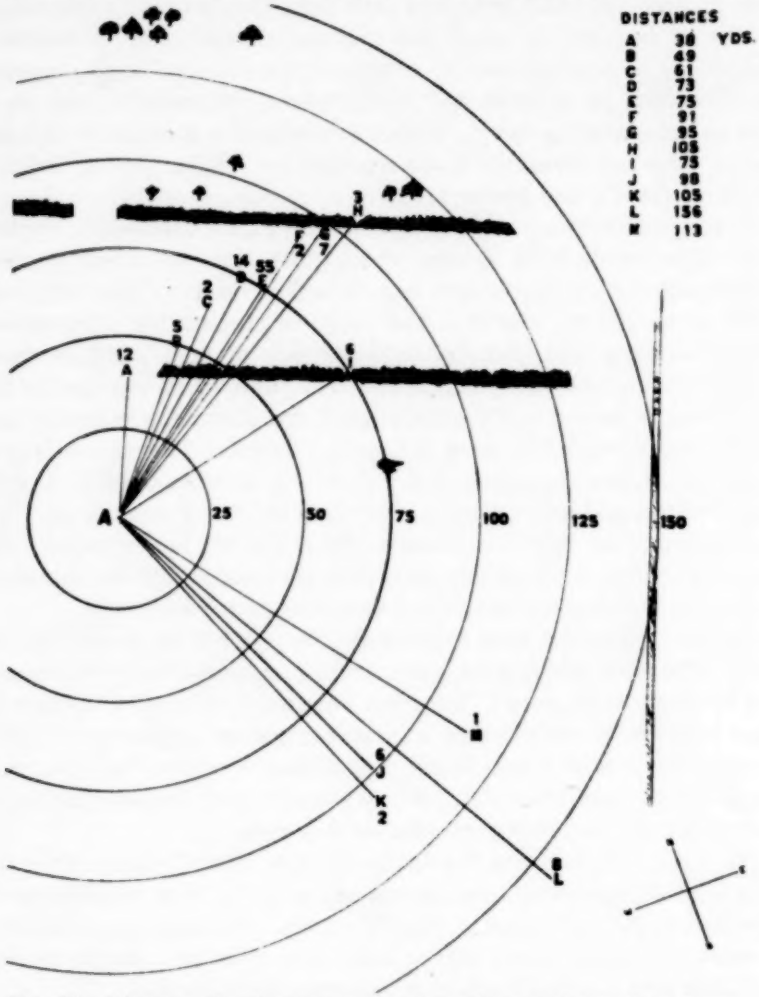

FIG. 34.—Diagram of release area showing release point at A and two arbor vitae hedges above. The concentric circles range from 25 to 150 yards in radius. Each letter indicates a recovery tree and the accompanying number, the total number of flies recaptured at that tree. The distances from the release point are given in yards at the upper right.

height and are densely planted. A group of seven medium sized apple trees comprised the release point. These release trees had previously been stripped of their fruit in order to provide an impetus for the flies to go elsewhere.

METHODS OF RELEASE AND RECAPTURE. In all, nine lots of flies were released at the same point but under varying conditions; some in late evening, some in the rain, some in wind, and others in bright sunshine. They were taken to the area in lantern globes. These globes were then opened and placed in the release tree or held under it.

TABLE 1. LONGEVITY RECORDS OF FLIES MARKED AND RECOVERED

	Gold marked (17)			Aluminum marked (44)		
Date	Minimum age in days	No. alive	No. dead	Minimum age in days	No. alive	No. dead
Aug. 12.....	20	16	1	7	39	5
Aug. 15.....	23	14	2	10	29	10
Aug. 17.....	25	9	5	12	21	8
Aug. 18.....	26	8	1	13	19	2
Aug. 22.....	30	3	5	17	10	9
Aug. 24.....	32	1	2	19	7	3
Aug. 28.....	36	1	0	23	7	0
Sept. 4.....	43	0	1	30	5	2
Sept. 9.....	—	—	–	35	4	1
Sept. 12.....	—	—	–	38	4	0
Sept. 18.....	—	—	–	44	4	0
Sept. 24.....	—	—	–	50	1	3
Sept. 25.....	—	—	–	51	0	1

A search of the neighboring apple trees was conducted at various periods during the course of the experiment which was begun on July 8 and terminated on August 7. The marked flies were recovered by the use of shell vials. As each fly was captured a note was made regarding the exact location, the sex of the individual, and the color of the mark, whether gold or aluminum. The writers failed to recover all the marked flies observed, but the individuals reported upon here were all actually caught and removed from the area, thus obviating the possibility of any marked fly being counted more than once.

LONGEVITY OF MARKED FLIES. Some of the marked flies, after recovery in the field, were confined in order to determine their length of life. Since the last gold marked flies were liberated on July 23 and the last aluminum marked individuals on August 5, the minimum length of life could be determined. The flies used in this experiment were originally collected in the release zone and, since they had undoubtedly emerged several days before being captured, their actual span of adult life must have been greater than the table indicates. The method of

marking employed in this experiment apparently did not affect the flies adversely.

Many of the flies lived for long periods of time including a record of over seven weeks in the case of four individuals. During this period the flies were fed on slices of apple, fresh pieces being introduced on an average of every other day. One or two decayed pieces were left in the cage and the flies fed on these to a considerable extent. All 66 flies under observation were plainly marked at the close of the experiment.

TABLE 2. RECORDS OF RECAPTURE

Position of recapture, distance traveled and tree variety	Date of recapture: July 17	July 21	July 22	July 23	July 28	Aug. 1	Aug. 3	Aug. 4	Aug. 5	Aug. 6	Aug. 7	Total
A—38 yards Gravenstein	3	–	3	–	1	–	–	1	3	–	1	12
B—49 yards Native	–	–	–	2	–	–	–	–	2	–	1	5
C—61 yards Nodhead	–	–	–	–	–	1	–	–	1	–	–	2
D—73 yards Baldwin	–	2	3	1	–	1	–	–	5	–	2	14
E—75 yards Greening	–	–	2	2	5	4	11	5	19	–	7	55
F—91 yards Astrachan	–	–	1	1	–	–	–	–	–	–	–	2
G—95 yards Baldwin	–	–	–	1	–	2	–	1	2	–	1	7
H—105 yards Greening	–	–	–	–	–	–	–	–	–	3	–	3
I—75 yards Baldwin	–	–	–	–	–	–	2	1	2	–	1	6
J—98 yards Baldwin	–	–	1	1	–	3	–	1	–	–	–	6
K—105 yards Nodhead	–	–	–	–	–	–	1	–	–	–	1	2
L—156 yards Greening	–	–	–	–	–	–	–	3	–	4	1	8
M—113 yards Williams	–	–	1	–	–	–	–	–	–	–	–	1
Total	3	2	11	8	6	11	14	12	34	7	15	123
Males	3	2	6	6	5	10	10	9	25	6	8	90
Females	0	0	5	2	1	1	4	3	9	1	7	33

In summarizing the foregoing data it might be pointed out that in all 1,035 marked flies were liberated. Of this number 123 were recovered at distances varying from 38 to 156 yards from the point of release. The recoveries were all made between July 17 and August 7. The greatest number collected on any one day was 34 on August 5. The percentage recovery was 11.8, a figure somewhat higher than those noted in connection with prior experiments with house flies or fruit flies.

Table 3 is a combined record of recoveries based upon three distance groupings. The records show that only 26.8 per cent were recovered within a radius of 75 yards. Over 56 per cent dispersed between 75 and 96 yards, and the remaining 16 per cent covered a distance varying from 98 to 156 yards.

TABLE 3. RECOVERY RECORDS GROUPED ACCORDING TO DISTANCE

Distance	Total No.	Males	Females	Per cent of total flies
38 to 73 yards	33	26	7	26.8
75 to 95 yards	70	48	22	56.9
98 to 156 yards	20	16	4	16.2

Considering the number of apple trees in the area selected and the range in varieties present, there was no particular reason, from the standpoint of food or oviposition, at least, for the flies to disperse more widely than they did. It is felt, however, that the flies might logically be expected to travel much greater distances in the absence of attractive fruits close at hand.

CONCLUSIONS

During the course of the experiment the direction of the wind changed many times. Thus, this particular stimulus would probably tend to spread the flies in many directions serving either as a vehicle to aid their flight or as an agent to convey attractive odors.

Rain always acts as an inhibiting influence preventing fly activity.

Temperatures below 60 degrees F. or above 90 degrees tend to reduce activity materially thus discouraging dispersal. On the other hand, temperatures between 75 and 85 degrees stimulate activity and encourage dispersal.

The two physiological factors of feeding and reproduction are undoubtedly the most important ones concerned with dispersal.

Natural barriers such as buildings and hedges probably exert an inhibiting effect upon dispersal. Three flies were taken just beyond the second arbor vitae hedge at a distance of 105 yards. Across an open field in the opposite direction a number of flies traveled over 50 yards further.

Dispersal is often a gradual process, the flies migrating from tree to tree in accordance with seasonal change in varietal preference.

Judging from our results, apple maggot flies will readily go 150 yards in search of desirable fruit. It is probable that under certain conditions they would travel much greater distances.

Neglected apple trees situated within 200 yards of commercial plantings should be sprayed or cut down. Systematic collection of the drops from such trees might serve as a substitute measure.

Literature Cited

Bourne, A. I. 1931. Insect Pests of Massachusetts Orchards in 1931. (*In* Massachusetts Fruit Growers' Assoc. Rept. 37:128–129.)

Brittain, W. H., and Good, C. A. 1917. The Apple Maggot in Nova Scotia. Nova Scotia Dept. Agr. Bul. 9:1–70, *illus.*

O'Kane, W. C. 1914. The Apple Maggot. New Hampshire Agr. Expt. Sta. Bul. 171:1–120, *illus.*

Parker, R. R. 1916. Dispersion of *Musca domestica* Linnaeus under city conditions in Montana. Jour. Econ. Ent. 9:325–354, *illus.*

Porter, B. A. 1928. The Apple Maggot. United States Dept. Agr. Tech. Bul. 66: 1–48, *illus.*

Severin, H. H. P. 1916. Control of Apple Maggot by Poisoned Bait Spray. Maine Agr. Expt. Sta. Bul. 251:165.

SOME NOTES ON THE CONTROL OF THE APPLE LEAFHOPPER *TYPHLOCYBA POMARIA* MCATEE

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Abstract

In New York State, leaves of mature apple trees often become stippled and devitalized as a result of feeding by the leafhopper *T. pomaria*. The species is two-brooded and overwinters in the egg stage on apple. In 1931 the first brood hatched in May; the second brood hatched during the latter half of August. The nymphs are readily killed by nicotine sprays, and since the duration in hatching of either brood was not long in 1931 it appears probable that a single correctly timed treatment may effect a high percentage kill of a brood.

No schedule of spraying has been recommended, heretofore, to New York fruitgrowers for the control of the apple leafhopper, *Typhlocyba pomaria* McAtee. Great swarms of this species have appeared in many of our apple orchards within recent years, spotting the fruit with their excreta, and stippling and even blanching the leaves as a result of feeding by the nymphs and adults. While fruitgrowers have exhibited concern over these attacks, only a few have made serious efforts to carry out control measures. There appears to be uncertainty in the minds of the majority that the marketability of the crop immediately subject to attack is appreciably affected or that the future productivity of the tree is impaired.

Infestations of the leafhopper have probably been more common in the Hudson River valley than in the fruit districts of Western New York, altho in Niagara county and in occasional orchards thruout this general area large numbers of the pest have been reported.

This paper is a preliminary note on studies of the leafhopper which are being made simultaneously in the Hudson valley and in western New York. Uppermost in our considerations has been a study of the seasonal developments of the species for the purpose of finding dates or correlations with bud development when insecticides could be advantageously applied.

The overwintering eggs of *T. pomaria* are laid during late September and in October in the bark of apple, where swellings readily attract attention to their location. Branches about one inch in diameter and smaller apparently bear most of the eggs. Eggs are also found in the larger limbs and even in one-year-old wood. Attempts to destroy the eggs with oil sprays (Diamond paraffin cold-mixed emulsion 6 and 8 per cent, and several commercial brands) and a tar wash (Barko 5 to 12½ per cent) applied at a dormant or semidormant condition of the trees have thus far been unsuccessful.

THE FIRST BROOD. The overwintered eggs of the leafhopper hatch during May. The hatching period in the two New York fruit districts appears to have been fairly closely parallel in 1931 when dates are compared. There is considerable divergence, however, in the appearance of the nymphs and bud development between the two areas. This rather surprising phenological phenomenon is shown graphically in Figure 35.

The season of 1931 has demonstrated, we believe, the possibilities of regional differences in the hatching period of this apple leafhopper and corrections which may be necessary in timing spraying operations for the pest. Some variation in the time of appearance of the nymphs was noticed in Hudson valley orchards, indicating that soil type, air and soil drainage and culture of the planting may also exert an influence.

That leafhopper nymphs are readily killed by nicotine sprays is well known, and *T. pomaria* is no exception. Thoro treatment with nicotine sulfate in combination with soap or a standard fungicide should result in a high percentage kill. Care must be taken to direct the spray to the undersides of the leaves where the hoppers are almost exclusively confined.

THE SECOND BROOD. Nymphs of the second brood appear during August. Spraying experiments carried out on the second brood in the Hudson valley in 1931 have thrown some light on the duration of the hatching period and also the treatment which may be followed for con-

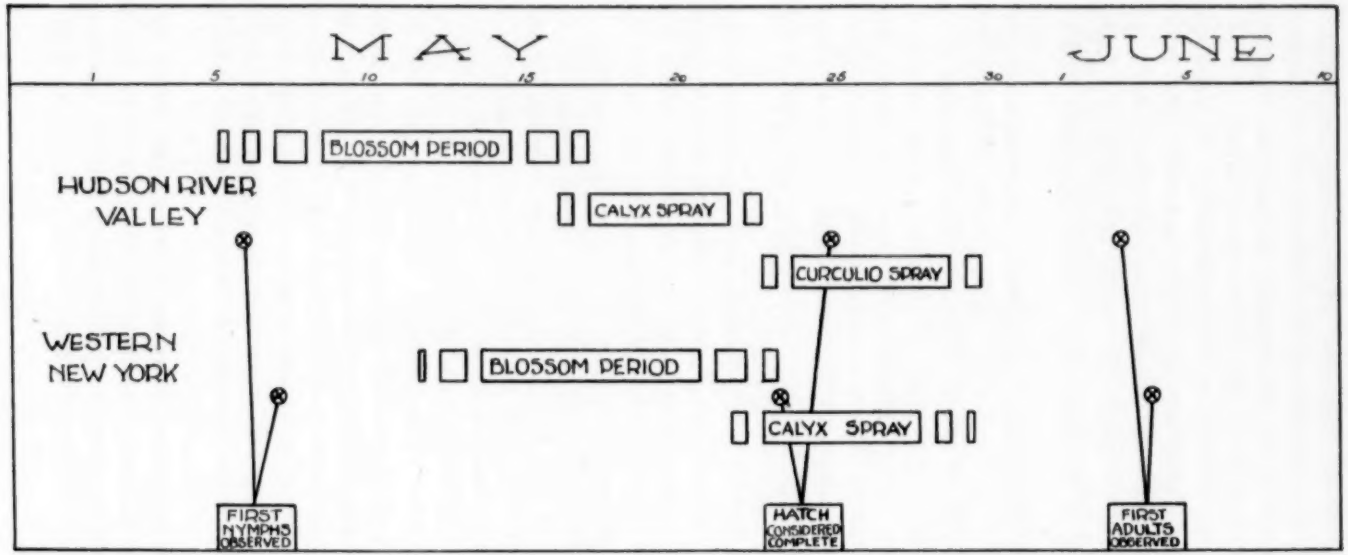

FIG. 35.—Hatching Period of First Brood *T. pomaria* Correlated with Blossom and Standard Spraying Periods, 1931.

trol. A young Rhode Island Greening orchard at Poughkeepsie, N. Y., was selected for these observations. Proceeding on the hypothesis that hatching might continue over a considerable period and thus necessitate more than a single treatment, we selected two spraying periods. On

TABLE 1. SPRAYING EXPERIMENTS AGAINST SECOND BROOD *T. pomaria*, 1931

No. tree	Material used	No. hoppers before spraying Aug. 26	After spraying count Aug. 27	No. hoppers before spraying Sept. 4	After spraying counts Sept. 5	Sept. 8	Sept. 15
1	Nicotine sulfate 1-800 and soap	1008	3[1]				
		920	not counted	44[2]	0	0	0
				1202	2	0	0
2	Nicotine sulfate 1-1600 and soap	641	8[1]				
		1235	not counted	64[2]	0	–	–
				1021	3	–	–
3	Nicotine sulfate 1-3200 and soap	1063	32[1]				
		1138	not counted	354[2]	11	–	23
				1023	19	–	1
4	Nicotine sulfate 1-3200 and Penetrol 1-200	896	23[1]				
		1262	not counted	393[2]	0	–	11
				1680	32	–	34
5	Sprayed water only.....	1281	1384	—	–	1542	–
		923	1457	—	–	1559	–

[1]Leaves removed to make count.
[2]Count made Sept. 2.
Ivory soap used in above tests, 4 lbs. in 100 gallons of spray.

the first, August 26, hoppers averaged six per leaf, and a large majority were in the first and second instars with extremely few advanced beyond the fourth instar. The second treatment was made September 4 since counts of both unsprayed trees and those treated with nicotine August 26 indicated a very small increase in new hoppers after September 1. On September 4 about 50 per cent of the insects were in the last three instars and an occasional adult was found. Results of these tests are given in Table 1.

A standard orchard power spraying machine and spray-gun were used in all tests. The material was applied as a mist spray under 400 pounds pressure.

The efficiency of copper compounds in controlling *Empoasca fabae* on potato and certain other plants has been pointed out by various workers, especially DeLong.[1] One of the junior authors (Reed) gives elsewhere

[1]De Long, D. M. The role of bordeaux mixture as a leafhopper insecticide. Jour. Econ. Ent. **22**:345–353. 1929.

in this volume of the Journal data on the susceptibility of *E. fabae* to bordeaux mixture with apple as the host. In Table 2 attention is called to tests of bordeaux mixture and Burgundy mixture against *T. pomaria*.

TABLE 2. TOXICITY TESTS AGAINST NYMPHS OF *T. pomaria*

Treatment	No. hoppers before spraying Sept. 2 or 3	After spraying counts Sept 3 or 4	Per cent control	Count Sept. 8	Per cent control based on Sept. 8 count
Ivory soap 1 lb.— 100 gals. water.....	1443	1113	22.9	1086	24.7
Ivory soap 2 lbs.— 100 gals. water.....	1055	612	42.0	409	61.2
Ivory soap 4 lbs.— 100 gals. water.....	1040	224	78.5	48	95.4
Penetrol 1-200.....	1364	857	37.2	492	63.9
Bordeaux 4-8-50.....	1515	736	51.4	466	69.2
Burgundy mixture 1-1 ½-50.....	934	932	.2	697	25.4

DISCUSSION

Contrary to expectations, the hatching period of both broods of *T. pomaria* was relatively short in 1931 and, consequently, a single carefully timed treatment would have effected a high percentage kill of either brood. Our observations indicated that May 22–25 was the period for using a contact insecticide against the first brood in 1931, and about September 1 (in the Hudson valley) against the second brood. Approximately 50 per cent of the hoppers were adults by September 15, and since adults and the large nymphs cause most of the leaf injury and fruit specking, treatments should be made as soon as possible after hatching is finished.

In discussing with fruitgrowers a program of control based on the observations placed on record here, the question invariably arises as to the possibility of getting so complete a kill of the first brood that treatment for the second brood becomes unnecessary. One can, of course, answer that thoroness of spraying and correct timing will determine in large degree the number of individuals surviving to produce a second brood. The other important consideration is the danger of reinfestation from untreated trees. Unless essentially all trees are carefully treated in a given planting, control measures would almost appear doomed to failure. A grower's efforts may likewise be largely vitiated by the unavoidable proximity to plantings not treated for the hopper. Aside from the direct purpose of controlling the second brood of this leafhopper is the probable benefit it will have in reducing the initial infestation for the following season.

EXPERIMENTS ON THE CONTROL OF *EMPOASCA FABAE* HARRIS ON YOUNG APPLE TREES

By T. W. REED, *Experiment Station, Geneva, N. Y.*

ABSTRACT

Bordeaux mixture and some contact insecticides were tested to determine their efficiency in controlling the nymphs of *Empoasca fabae* Harris on apple nursery stock. Nicotine sulfate, when mixed with soap or dry-mix, was effective in killing the nymphs. Bordeaux mixture, when used at the rate of 2–2–50 or stronger, resulted in a high degree of control.

The potato leafhopper (*Empoasca fabae* Harris) has long been known as a serious pest of apple nursery stock. The feeding of this insect produces a characteristic curling of the end and the edges of the leaf, with a consequent puckering of the upper surface. During hot, dry weather these curled ends and edges turn yellow, then brown or black, presenting the distinctive condition known as "hopper burn." Continued feeding of this pest not only stunts the growth but produces a bushy appearing tree, due to the development of the lateral buds into slender branches bearing small, ill-formed leaves. This injury impairs the quality of the nursery stock offered for sale by the grower.

Lathrop (1) in 1918 recommended the use of nicotine and soap at standard strengths for the control of this insect. He states that thoro drenching of the insects is necessary; also that the best control can be obtained by dipping the growing tip into a pail of the spray material. This latter practice is the one that local nurserymen have found necessary to use to control this pest. This is a laborious and time-consuming job and must be repeated frequently to afford adequate protection.

A spray mixture that is cheap, effective, and easily applied and which also eliminates the necessity of repeated applications would be a decided advantage in controlling this pest. With this objective in mind several contact insecticides and bordeaux mixture were applied. De Long (2) in 1929 demonstrated that when bordeaux mixture was applied to the leaves of beans copper was absorbed by the plant and that this treatment was toxic to nymphs and adults of *E. fabae*.

EXPERIMENTAL WORK. During 1930 three sets of experiments were conducted. These were carried out in a nursery containing three-year-old McIntosh stock about four feet in height. Each plat consisted of three rows 75 feet long, and in Experiment No. 1 each plat was duplicated in alternate opposite ends of the block. One or two untreated plats in each block were left for a check for each experiment. The spray was applied with a 100-gallon Friend rig carrying 200 pounds pressure,

using a regular single gun equipped with a disc, the aperture of which was of medium size. This outfit delivered the spray as a mist with sufficient force to turn the leaves over when hit so that the under surfaces of the leaves were wetted with the spray.

The counts were made two days after application, and since the nymphs congregate on the growing tips the population on a definite number of these selected at random in each plat was used as a basis for comparison. No attempt was made to check up on the adult hoppers as they were present only in small numbers and probably were continually migrating to and from the nursery.

Experiment No. 1.—The relative toxicity of some contact insecticide mixtures used against the nymphs of *E. fabae*. Spray applied July 19, 1930; counts made July 21, 1931.

TABLE 1. RESULTS OF TREATMENTS AGAINST *E. fabae* NYMPHS ON APPLE NURSERY STOCK, 1930

Treatment	Number tips counted	Number live nymphs	Average per tip	Percentage control	Injury
Potash fish-oil soap (32% soap) 12 lbs. per 100 gals	300	654	2.18	72.03	None
Penetrol ½% Nicotine sulfate 1-1600	300	1186	3.62	49.29	None
Summer oil emulsion 1%	300	1149	3.51	50.86	None
Summer oil emulsion 1% Nicotine sulfate 1-3200.....	300	918	3.06	60.74	None
Summer oil emulsion 1% Nicotine sulfate 1-1600	300	868	2.56	62.88	None
Summer oil emulsion 1% Nicotine sulfate 1-800.....	300	787	2.62	66.34	None
Neococotine ½%	300	1070	3.56	54.24	Slight
Neococotine ½% Nicotine sulfate 1-1600	300	844	2.71	63.9	Slight
Dry-mix 24 lbs. per 100 gals. Nicotine sulfate 1-800	300	128	.42	94.53	None
Check	300	2338	7.79	0.0	——

Experiment No. 2.—The relative toxicity of some contact insecticide mixtures used against the nymphs of *E. fabae*. Spray applied July 25, 1930; counts made July 26, 1930

TABLE 2. RESULTS OF TREATMENTS AGAINST *E. fabae* NYMPHS ON APPLE NURSERY STOCK, 1930

Treatment	Number tips counted	Number live nymphs	Average per tip	Percentage control	Injury
Dry-mix 24 lbs. per 100 gals. + nicotine 1 pt.	100	16	.16	97.59	None
Sodium oleate soap (So-fyne) 2 gals. per 100 gals. Evergreen 1-1200	100	4	.04	99.40	None
Potash fish-oil soap (32% soap) 4 lbs. per 100 gals. Nicotine sulfate 1-800	100	82	.82	87.64	None
Neococotine 1%	100	5	.05	99.25	Severe
Sodium oleate soap (So-fyne) 2 gals. per 100 gals. Nicotine sulfate 1-2400	100	22	.22	96.69	None
Potassium oleate soap 6 lbs. per 100 gals. Nicotine sulfate 1-2400	100	48	.48	92.77	None
Check	100	663	6.63	—	—

Experiment 3.—The toxicity of various concentrations of bordeaux mixture to the nymphs of *E. fabae*. Spray applied July 19 and July 25, 1930.

TABLE 3. THE TOXICITY OF BORDEAUX MIXTURE TO *E. fabae* ON APPLE NURSERY STOCK, 1930[1]

Treatment	Date of application	No. live nymphs after 2 days	Check	Percentage control	After 5 days	Check	Percentage control	After 11 days	Check	Percentage control
Bordeaux 4-4-50 Nicotine sulfate 1-800	July 19	76	685	89.01	40	483	91.72	10	418	97.61
Bordeaux 4-4-50	July 19	29	685	95.77	—	—	—	—	—	—
Bordeaux 2-3-50	July 25	51	483	89.45	0	418	100.00	—	—	—
Bordeaux 3-3-50	July 25	54	483	88.82	2	418	99.53	—	—	—
Bordeaux 4-4-50	July 25	34	483	92.97	0	418	100.00	—	—	—

[1]Counts made on the basis of 50 tips.

In this experiment the trees were more severely infested and the leaves were more tightly curled so that it was impossible to wet the

under surfaces of leaves and thus hit many of the nymphs. While making the counts two days after applying the bordeaux mixture numerous dead nymphs were observed, many of these having died during the process of ecdysis. All of the nymphs found while making the 11-day counts were very small first-instar nymphs which had apparently just hatched. Many badly curled leaves would, when uncurled, expose several dead nymphs which were untouched by the spray and had been feeding on leaves, the under surfaces of which had not been wetted by the spray.

Little growth was made by any of the plats during the latter part of August, and as the foliage and tips became hardened the leafhopper population was small and did little damage. The nymphs soon appeared in approximately equal numbers on all of the plats treated with the contact insecticides. However, the plats treated with bordeaux remained free from nymphs except a few on what new growth appeared during the remainder of the summer.

Experiment No 4.—This experiment was conducted during 1931. It was carried out on one-year-old McIntosh nursery stock standing about 18 inches to 2 feet in height. The leaves were just beginning to curl, and the nymphs found on them were in all stages, mostly in the first, second, and third instars; some being in the fourth and fifth. The spray was applied in exactly the same manner as in 1930, and the same equipment was used. The results are shown in Table 4.

TABLE 4. THE TOXICITY OF BORDEAUX MIXTURE TO *E. fabae* ON APPLE NURSERY STOCK, 1931[1]

Treatment	Number live nymphs after 3 days	Percentage control	Number live nymphs after 10 days	Percentage control
Bordeaux 2-2-50	466	53.26	24	96.18
Bordeaux 2-3-50	317	68.11	3	99.52
Bordeaux 2-4-50	227	77.23	3	99.52
Bordeaux 2-6-50	280	71.92	21	96.66
Bordeaux 2-8-50	225	77.43	6	99.04
Bordeaux 1-1-50	544	45.44	63	89.95
Bordeaux 3-3-50	359	64.00	24	96.18
Bordeaux 3-4½-50	195	80.44	6	99.04
Bordeaux 4-6-50	303	69.41	6	99.04
Nicotine sulfate 1-800 Lime 4 lbs., Kayso 1 lb.	270	72.92	399	36.37
Check	997	——	627	——

[1]Counts made on the basis of 75 tips.

Table 4. The toxicity of various concentrations of bordeaux mixture to the nymphs of *E. fabae* on apple nursery stock. Spray applied July 21, 1931.

Rain began to fall shortly after these applications were made and the

weather was warm and damp for three days, during which time the trees grew very rapidly. Apparently these conditions did not destroy the toxic action of the bordeaux mixture. However, it appeared to slow up the death rate of the insects. As in 1930, many, but not all of the dead nymphs observed, had died during ecdysis; also all of the nymphs found on the trees at the time of the 10-day count were very small first-instar nymphs.

The summer of 1931 was favorable to the growth of this nursery stock, and by the middle of August there was about six or eight inches of new growth on each tree. This was infested with young nymphs (about 8 nymphs per tip), and another application of bordeaux was necessary. This kept the trees fairly free from hoppers until the trees had ceased growing for the season.

Conclusions

1. Bordeaux mixture when applied as a spray on apple nursery stock affords good control of *Empoasca fabae* nymphs.
2. Increasing the concentration of the bordeaux above 2–2–50 does not increase the toxicity, nor does the presence of extra lime change the effect of the spray.
3. Soap or dry-mix, when used as a carrier for nicotine sulfate, was efficient in killing the nymphs of *E. fabae*.

Literature Cited

1. Lathrop, F. H. Leafhoppers injurious to apple trees. N. Y. Agr. Exp. Sta. Bul. 451, Geneva, Sept. 1918.
2. DeLong, D. M. Jour. Econ. Ent. Vol. 22, pp. 345–353, April 1929.

An addition to the list of parasites of the Sunflower weevil, *Desmoris fulvus* (Lec). During the examination of sunflower seeds collected in November 1931 for the presence of the Sunflower Weevil (*Desmoris fulvus* Lec.) one specimen of a parasite of these insects was found that has not been previously reported.

Parasites were found in eight of the eleven lots of seed examined from the area where infestation has been general for several years. Of these parasites it was possible to rear eleven specimens. Ten of these were *Microbracon mellitor* (Say) and one was *Eupelmus cyaniceps* var. *amicus* (Girault), the latter being the new find. Determinations were made by H. H. Ross.

It appears that *M. mellitor* (Say) might develop into an important help in control of the Sunflower Weevil, as it has been found in all examinations of infested seeds.

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A PRELIMINARY STUDY OF THE INSECTICIDAL EFFICIENCY OF THE PYRETHRINS, NICOTINE AND ROTENONE AGAINST THE GREENHOUSE RED SPIDER MITE

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ABSTRACT

Without the addition of some wetting agent, the pyrethrins, rotenone, and nicotine, even at high concentrations, have little toxicity to the greenhouse red spider mite. With the addition of 0.25 per cent potassium oleate soap, rotenone at 0.02 per cent is slightly more toxic than the pyrethrins (0.02 per cent); nicotine is much less toxic than either of these two, approximately 0.66 per cent being necessary to produce a mortality equivalent to that produced by the above concentrations of the other two poisons. With sulphonated castor oil as the wetting agent, the pyrethrins and rotenone at 0.02 per cent are about equivalent in toxicity; nicotine again is much less toxic, about 0.2 per cent being necessary to equal the insecticidal efficiency of the other two at the concentrations given above. Potassium oleate soap at 0.25 per cent and 0.5 per cent is approximately equivalent in toxicity to sulphonated castor oil at 0.5 per cent and 1 per cent, respectively. Soap is more efficient than sulphonated castor oil as a wetting agent for rotenone and the pyrethrins. With nicotine, however, the reverse appears to be true. Nicotine (1–500) makes distinctly alkaline the almost neutral 0.5 per cent sulphonated castor oil, but has a relatively slight effect on the already alkaline soap solution. Alcoholic extracts of the pyrethrins have an acidic effect when added to either sulphonated castor oil or soap solution. Acetone solutions of rotenone have very little effect on the pH of either of these wetting agents.

Two comparatively new contact insecticides have recently been developed for use in insect control: the pyrethrins found in extracts from pyrethrum or insect powder, the ground flower heads of the chrysanthemum daisy (*Chrysanthemum cinerariaefolium* Vis.), and rotenone, a constituent extracted from derris (*Derris elliptica* (Wall.) Benth.) and other so-called "fish-poison" plants of the tropics. Inasmuch as these two new insecticides will come into competition with nicotine, one of our most useful insect poisons, information is needed on the comparative efficiency of these three materials.

This paper reports some preliminary results of tests comparing the insecticidal efficiency of nicotine, rotenone, and the pyrethrins against the greenhouse red spider mite (*Tetranychus telarius* L.).[1] Water dilutions of each of these poisons were first tested. Following that, the combinations with each of two different wetting agents were investigated. The hydrogen-ion concentrations of the various solutions were also studied.

[1]The author wishes to acknowledge the identification of this mite by Dr. H. E. Ewing, Bureau of Entomology, Washington, D. C.

Davidson (2) has reported that rotenone applied as a water suspension without the addition of a wetting agent was relatively ineffective against the red spider mite.

Darley (1), in tests of combinations of the pyrethrins, rotenone, and nicotine sulphate with sulphonated oxidized petroleum oil against the red spider mite, found that rotenone was more toxic than the pyrethrins, and these two materials, in turn, were considerably more toxic than nicotine sulphate.

EXPERIMENTAL MATERIALS AND METHODS. The following chemicals were used in these experiments:

Rotenone (m. p. 163°C.).—A sample was obtained from the Bureau of Chemistry and Soils.[2] A 3 per cent (by weight) solution in acetone was freshly prepared for each series of experiments.

Pyrethrins.—An alcoholic solution of the pyrethrins was prepared by extracting pyrethrum powder, guaranteed by the importer to contain 1.06 per cent of pyrethrins.[3] The powder was completely extracted with petroleum ether (30–60°C.) in a Soxhlet apparatus. After extraction was complete, the volatile solvent was taken off under reduced pressure and the oily residue taken up in ethyl alcohol.

Nicotine (e. p.).—A sample was obtained from the Bureau of Chemistry and Soils.[4] This sample had recently been redistilled under reduced pressure, so that the compound was at least 99.5 per cent pure.

Soap.—Potassium oleate soap was prepared from oleic acid and potassium hydroxide (C. P.) in this laboratory.

Sulphonated castor oil (U. S. P.).—Specific gravity 1.003 at 25°C. Hydrogen-ion measurements were made with a potentiometer (checked by the United States Bureau of Standards); both hydrogen and quinhydrone electrodes were used.

All the sprays were prepared with distilled water and the applications were made as soon as the dilutions were prepared. The sprays were applied by means of a small hand atomizer (at a constant pressure of 5 pounds per sq. in.—351 gms. per sq. cm.) to infested Kudzu leaves (*Pueraria thunbergiana* Benth.). The nozzle was held approximately

[2]Through the courtesy of Dr. R. C. Roark.

[3]This powder had been stored in a tight, brown-glass bottle which was kept in a darkened closet for a period of 11 months. Tattersfield and Hobson (6) reported that pyrethrum powders retain their insecticidal properties for considerable periods of time (18 months in their experiments) if stored in closed vessels. A very recent paper has just come to my notice by Gnadinger and Corl (Industrial and Engineering Chemistry, 1932, in press) in which considerable deterioration has been reported even when the powder was stored in tight, vacuum-sealed tin cans for a period of 1 year. There is apparently still some disagreement as to the stability of pyrethrum powder. If pyrethrum powder does lose some of its active principles, the amounts of pyrethrins dealt with here are somewhat less than indicated.

[4]Through the courtesy of H. D. Young.

6 inches from the leaf and the spray applied until the leaf was thoroughly wet. Spraying was done at room temperature (24–28°C.) and as soon as completed the sprayed leaves were placed in vials and transferred to a constant temperature and humidity chamber (temp. 26 ± 1.5°C., humidity 60 ± 4 per cent). Papers lined with sticky tree-banding material were placed under each vial so that escaping mites were caught.

Since preliminary tests showed that mortality counts of adult red spider mites did not change appreciably for any of these insecticides after 24 hours, counts were made from 24 to 48 hours after the spray applications. Only the adult mites were used in these tests.

TABLE 1. TOXICITY TO THE GREENHOUSE RED SPIDER MITE OF ROTENONE, NICOTINE, AND THE PYRETHRINS, WITHOUT THE ADDITION OF WETTING AGENTS, OCTOBER, 1931

Material[1]	Concentration Per cent by weight	Total number of mites	Number of dead mites	Mortality Per cent
Pyrethrins	0.02	106	23	21.7
Rotenone	0.02	139	17	12.2
Nicotine	0.2	123	8	6.5
Control	—	143	13	9.1
Untreated check	—	90	5	5.6

[1]Each solution contained 2 per cent alcohol and 0.66 per cent acetone in addition to the principal toxic agent. This was necessary because rotenone was added as an acetone solution, pyrethrins as an alcoholic solution. The control consisted of 2 per cent alcohol with 0.66 per cent acetone.

TESTS WITHOUT THE ADDITION OF WETTING AGENTS. Preliminary tests made without the addition of wetting agents indicated that rotenone 1–5000 (0.02 per cent), the pyrethrins 1–5000 (0.02 per cent), and nicotine 1–500 (0.2 per cent) had very little toxic action on the red spider mite. The concentrations of poison used in these tests are quite high for each of these insecticides. The results are shown in Table 1.

From these results it appeared to be desirable to add some agent which would give better wetting and penetrating powers to the spray. Hence experiments were conducted with each of two wetting agents, potassium oleate soap and sulphonated castor oil.

EXPERIMENTS WITH SOAP AS A WETTING AGENT. Potassium oleate soap at both 1–400 (0.25 per cent) and 1–200 (0.5 per cent) concentrations was tested. The toxicity of 0.25 per cent potassium oleate soap was low—mortality varied between 8 and 11 per cent when that of the untreated checks was 3 to 8 per cent; that of 0.5 per cent potassium oleate was distinctly higher—from 22 to 26 per cent under the same conditions.

Preliminary experiments were conducted with high, medium, and low concentrations of nicotine, rotenone, and the pyrethrins in combination with 0.25 per cent soap solutions in order to ascertain the approximate

concentration of each insecticide that would kill about 50 per cent of the mites. As Fisher has brought out in a paper by Tattersfield and Morris (7), the most accurate comparison can be made of the toxicity of insecticides when the concentrations are such that about 50 per cent of the insects perish. If the concentrations necessary to kill 90 to 100 per cent of the insects were tested, many thousands of individuals would have to be used in order to have enough surviving insects to permit an accurate comparison of the insecticides. The results of this series are shown in Table 2. As these tests were all made on the same day under the same conditions, and the mites were all apparently of the same population, the mortality data are comparable.

TABLE 2. MORTALITY OF THE RED SPIDER MITE WHEN SPRAYED WITH VARIOUS CONCENTRATIONS OF NICOTINE, ROTENONE, AND THE PYRETHRINS IN COMBINATION WITH 0.25 PER CENT POTASSIUM OLEATE SOAP

Material	Concentration Per cent	Total number of mites	Number of dead mites	Mortality Per cent
Rotenone	0.005	163	21	12.9
	.02	98	77	78.6
	.1	144	120	83.4
Pyrethrins	.005	133	19	14.3
	.02	75	34	45.4
	.1	87	84	96.5
Nicotine	.05	122	16	13.1
	.2	207	52	25.1
	.66	121	49	40.5
Untreated control	——	90	5	5.6

It appears from this study that approximately 0.02 per cent pyrethrins (1–5,000), 0.02 per cent rotenone (1–5,000), and 0.66 per cent nicotine (1–150) are necessary in order to obtain a mortality near the 50 per cent point. Accordingly, concentrations of the various insecticides near these amounts were next tested. Both the 0.5 per cent and 0.25 per cent strengths of potassium oleate were tried as wetting agents. The data are given in Table 3.

A study of the experiments in which soap is used as the wetting agent indicates that at a concentration of 0.02 per cent rotenone is somewhat more toxic than the pyrethrins. In those tests where 0.25 per cent soap was used (series 3 and 4) rotenone averaged 63.9 per cent, the pyrethrins 38.1 per cent. These differences were analyzed statistically by Fisher's method (*4, p. 99*) for the determination of the significance of a mean difference. The procedure has been illustrated in a previous paper (*5*). An analysis of the data from tests with the 0.25 per cent soap solution gave a t value of 5.89. This in turn corresponds to a probability, P, of

TABLE 3. MORTALITY OF THE RED SPIDER MITE WHEN SPRAYED WITH NICOTINE, ROTENONE, AND THE PYRETHRINS IN COMBINATION WITH POTASSIUM OLEATE SOAP AND WITH SULPHONATED CASTOR OIL AS WETTING AGENTS[1]

Insecticide	Concentration of insecticide	Potassium oleate soap 0.5 per cent Series 1	Series 2	Series 3	Series 4	Series 5	0.25 per cent Series 3[2]	Series 4	Series 5	Sulphonated castor oil 1.0 per cent Series 2	0.5 per cent Series 3	Series 4
	Per cent by weight	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Pyrethrins	.02	33.4	47.7	—	—	—	45.4	38.2[3]	—	38.3	29.7	24.1
								30.6				
	.05	—	57.2	—	—	—	—	—	35.8	—	—	—
	.1	94.0	—	—	—	—	—	—	—	—	—	—
Rotenone	.02	65.0	54.0	—	—	—	78.6	56.4[3]	—	53.4	35.1	25.0
								56.7				
	.05	—	55.3	—	—	—	—	—	44.8	—	—	—
	.1	67.0	—	—	—	—	—	—	—	—	—	—
Nicotine	.2	—	58.3	—	—	—	25.1	—	—	81.5	47.4	22.2
	.66	—	—	—	—	—	40.5	32.5[3]	—	—	—	—
								40.9				
	1.0	—	—	—	—	—	—	—	30.3	—	—	—
Wetting agent alone	—	26.6	22.9	24.2	26.4	22.4	11.0	8.8	10.1	23.2	14.0	13.6
Untreated check	—	5.4	3.1	5.6	8.8	7.8	5.6	8.8	7.8	3.1	5.6	8.8

[1]In each test approximately 100 or more mites were used. It must be remembered that each series is complete for a single day. Comparisons can only be made within that series, though by pairing the experiments comparisons can be made of the average values for two or more substances in several series.

[2]A number of the values from Table 2 are included in Series 3 for use in the statistical analysis.

[3]Two separate experiments were made on the same day.

approximately 0.03. Where the probability of obtaining such a large difference is only 3 in 100 by chance, it appears that these differences in the toxicity of rotenone and the pyrethrins are real, especially since this value was derived from only three paired tests; that is, rotenone is slightly but distinctly more toxic than the pyrethrins at this concentration. Scarcely enough experiments have been made with the two poisons using the 0.5 per cent soap solution to make a statistical analysis, though the differences in the average values (rotenone 59.5 per cent, pyrethrins 40.5 per cent, series 1 and 2) certainly suggest that a real difference is present.

At a higher concentration, 1-2000 (0.05 per cent), rotenone and the pyrethrins appear to be about equal in toxicity. At a still higher concentration, 1–1000 (0.1 per cent), the pyrethrins appear to be slightly more toxic than rotenone—i.e., rotenone seems to approach a limit in its toxic action much faster than the pyrethrins—though these concentrations have not been investigated sufficiently to permit any definite conclusions to be drawn.

A comparison of the toxicity of nicotine with that of the pyrethrins in series 3 and 4 shows that 0.66 per cent nicotine is about equivalent to 0.02 per cent pyrethrins (nicotine averaged 37.9 per cent, pyrethrins 38.1 per cent). Nicotine is certainly much less toxic than the other two poisons. In these experiments over 30 times as much nicotine (0.66 per cent) was necessary to obtain the same toxicity as that obtained with the pyrethrins or rotenone (each at 0.02 per cent).

Sulphonated Castor Oil as a Wetting Agent. Sulphonated castor oil is an entirely different type of wetting agent from soap. Known commercially as turkey red oil, it is used to prepare cotton fibre for dyeing and printing. The water-soluble constituent present here is said to be ricinoleo-sulphuric acid.

The pH value of a 0.5 per cent solution (pH 6.6) of sulphonated castor oil is distinctly lower than that of a 0.25 per cent solution of potassium oleate (pH 10.04). That is, the sulphonated castor oil is nearly neutral, while the soap is distinctly alkaline. Differences in the effect of the two wetting agents on the insecticidal efficiency of these sprays might, therefore, be expected. Compared with soap in the same series, 0.5 per cent and 1 per cent sulphonated castor oil appeared to be about equivalent in toxicity to potassium oleate soap at 0.25 per cent and 0.5 per cent, respectively.

Nicotine at 1–500 (0.2 per cent), rotenone at 1–5000 (0.02 per cent), and the pyrethrins at 1-5000 (0.02 per cent) were tested in combination with sulphonated castor oil. The results are shown in Table 3.

In those tests where 0.5 per cent sulphonated castor oil was used, rotenone and the pyrethrins, each at 0.02 per cent, averaged 30.0 and 26.9 per cent mortality, respectively, while nicotine at ten times the above concentration (0.2 per cent) averaged 34.8 per cent mortality. Though this number of tests is rather small for statistical analysis, such analysis (*4, p. 99*) showed no significant differences. With sulphonated castor oil, rotenone and the pyrethrins at 0.02 per cent appeared to be equivalent in toxicity. Nicotine, on the other hand, was much less toxic than the pyrethrins or rotenone; though with sulphonated castor oil it was much nearer in toxicity to these two poisons than with soap as the wetting agent. However, these differences were still great.

All three insecticides appeared to be more efficient when combined with the higher concentration of sulphonated castor oil.

Comparison of Sulphonated Castor Oil and Potassium Oleate Soap as Wetting Agents. There appears to be a distinct difference in the efficiency of these two substances as wetting agents for nicotine, rotenone, and the pyrethrins. As both sulphonated castor oil and soap were tried as wetting agents in the same series—that is, in the tests made on the same day—direct comparisons can be made of the values in series 2, 3, and 4. At the equivalent toxic concentrations—i.e., soap 0.25 per cent, sulphonated castor oil 0.5 per cent—soap is more efficient as a wetting agent for both rotenone and the pyrethrins.

The data on nicotine bring out just the opposite indication. With both the high and low concentrations of the two wetting agents, nicotine at 0.02 per cent killed a distinctly higher percentage of the mites when combined with sulphonated castor oil than when soap was used as the wetting agent. Sulphonated castor oil, therefore, appears to be much more efficient than soap as a wetting agent for nicotine.

Hydrogen Ion Studies

Table 4. Hydrogen-ion Concentrations of Solutions of Different Wetting Agents and of Combinations of these with Pyrethrins, Rotenone, and Nicotine (made with the Quinhydrone and Hydrogen Electrodes at 22° C.)

Wetting agents	Wetting agent alone	Wetting agent combined with—		
		Pyrethrins 0.02 per cent	Rotenone 0.02 per cent	Nicotine 0.2 per cent
	pH	*pH*	*pH*	*pH*
Sulphonated castor oil (0.5 per cent)	6.60	5.20	6.19	8.45
Potassium oleate soap (0.25 per cent)	10.04	8.40	9.86	9.96

As shown in the data of Table 4, nicotine had little effect on the pH of the soap solution, but it made distinctly alkaline the almost neutral

sulphonated castor oil solution. Rotenone (added as an acetone solution) had only a very slight effect on the pH of either of the wetting agents. Alcoholic extracts containing the pyrethrins had a distinctly acidic effect; the pH of both the wetting solutions was lowered considerably.

Tattersfield and Hobson (6) have recently reported that pyrethrum extracts are more permanent, even in the presence of alkalies, than has usually been supposed. As demonstrated in Table 4, the addition of these extracts to soap solutions no doubt tends to neutralize the free alkali. This fact might account for the unexpected stability which Tattersfield and Hobson found for pyrethrum extracts when combined with concentrated and dilute alkaline solutions.

The observation is made that most efficient solutions were all of an alkaline nature, but further investigation is needed before any definite conclusions may be drawn.

Literature Cited

1. Darley, M. M. Some Comparative Tests with Rotenone, Nicotine, and Pyrethrum. Jour. Econ. Ent. *24*:111–115 (1931).
2. Davidson, W. M. Rotenone as a Contact Insecticide. Jour. Econ. Ent. **23**: 868–874 (1930).
3. ————, and Jones, H. A. Change in Toxicity of Rotenone in Solution and Suspension. Jour. Econ. Ent. *24*:257–262 (1931).
4. Fisher, R. A. 1930 Statistical Methods for Research Workers. p. 283 3rd Ed. Edinburgh.
5. Richardson, H. H. The Pyrethrin I Content of Pyrethrum Powder as an Index of Insecticidal Power. Jour. Econ. Ent. 24:1098–1106 (1931).
6. Tattersfield, F., and Hobson, R. P. Extracts of Pyrethrum: Permanence of Toxicity and Stability of Emulsions. Ann. Appl. Biology 18:203–243 (1931).
7. ————, and Morris, H. M. An Apparatus for Testing the Toxic Values of Contact Insecticides under Controlled Conditions. Bul. Ent. Res. *14*:223–234 (1924).

EXPERIMENTS WITH WAXES AS POSSIBLE CARRIERS OF INSECTICIDES[1]

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Abstract

The effect on foliage and the toxicity to insects of various solid waxes were studied under greenhouse and orchard conditions. The waxes were emulsified with triethanolamine oleate and impregnated with pyrethrum and derris extracts. Apple aphis and silk moth caterpillars were used for testing.

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

Summer oil sprays are often accompanied by appreciable injury to plants, especially (2) the apple tree. Emulsified, refined petroleum oils are coming more and more into use in apple orchards as stickers in combination with lead arsenate (8), as ovicides in codling moth control, and as carriers of pyrethrum (5) and nicotine (6) used as arsenical substitutes. This movement towards summer oil insecticides is due partly to the need of the orchardist for an arsenical substitute which should not require washing of fruit, and partly to an incessant campaign of the various oil companies interested in the manufacture and sale of oil emulsions. Which part is the more causative factor in the increased use of oil the writer is not ready to say.

The injury resulting from oil sprays is more or less of a cumulative nature and is caused primarily by the oil penetrating into leaf tissue (3). A search was, therefore, made for chemicals which should be similar in their sticking properties to oils and would not penetrate into plant tissue. The various waxes suggested themselves for this purpose.

Experimental

Members of each of the three groups of waxes, namely, vegetable, animal, and paraffin were selected for testing. Waxes derived from plant and animal sources are, with the exception of sperm oil, solid at room temperature The waxes tested included bay, bee, candelilla, carnauba, Chinese, Japan, montan, myrtle, spermaceti and several paraffin waxes of different melting points. Of these waxes the following four have given suitable emulsions for spraying purposes and were, therefore, selected for testing on plants and insects: spermaceti melting at 44°C., candelilla melting at 68°C., and two paraffin waxes melting at 42°C. and 55°C. respectively. The physical and chemical properties of these waxes are fully described in Lewkowitsch (7) Gruse (4), and Bacon and Hamor (1).

The following procedure was employed in emulsifying waxes. About 5 gms. of triethanolamine oleate were dissolved in 75 cc. of water heated to boiling and transferred to the mixing machine. About 25 cc. of melted wax, heated 10 or 15 degrees above its melting point, were then added to the water with constant stirring. The mixing was continued for about 5 minutes. To prevent the solidification of the wax before the emulsification was completed the mixing apparatus was placed in a water bath, heated to about 90°C. or higher. Thus emulsified the wax is broken up into fine particles and forms a colloidal suspension when diluted with water. All the waxes tested in this investigation were emulsified by the above formula.

Tests for Penetration of Waxes into Plant Tissue. The pene-

tration tests were carried out in a manner similar to that already described in a previous publication (3) on "Penetration of Petroleum Oils into Plant Tissue." Briefly, about 0.1% of Sudan III (oil soluble dye) was incorporated into the melted wax before emulsification. This

TABLE 1. TESTS WITH WAX EMULSIONS ON APPLE TREES GROWN IN THE GREENHOUSE

Wax used	% Wax	Surface of leaf treated	Date sprayed	Spray repeated	Injury observed	Nature of injury
Candelilla.....	2	Upper	4–2–31	4/15 4/23	None	
Candelilla.....	2	Under	4–2–31	4/15 4/23	None	
Candelilla.....	4	Upper	4–2–31	4/15 4/23	None	
Candelilla.....	4	Under	4–2–31	4/15 4/23	None	
Candelilla.....	25	Upper	3–31–31	4/15 4/23	None	
Candelilla.....	25	Under	3–31–31	4/15 4/23	None	
Paraffin 42° C.	2	Upper	4–2–31	4/15 4/23	None	
Paraffin 42° C.	2	Under	4–2–31	4/15 4/23	None	
Paraffin 42° C.	4	Upper	4–2–31	4/15 4/23	None	
Paraffin 42° C.	4	Under	4–2–31	4/15 4/23	None	
Paraffin 42° C.	25	Upper	3–31–31	—— ——	4–4–31	Brown spots on leaves
Paraffin 42° C.	25	Under	3–31–31	—— ——	4–3–31	Brown spots followed by leaf drop
Paraffin 55° C.	2	Upper	4–2–31	4/15 4/23	None	
Paraffin 55° C.	2	Under	4–2–31	4/15 4/23	None	
Paraffin 55° C.	4	Upper	4–2–31	4/15 4/23	None	
Paraffin 55° C.	4	Under	4–2–31	4/15 4/23	None	
Paraffin 55° C.	25	Upper	3–31–31	—— ——	4–11–31	Brown spots on leaves
Paraffin 55° C.	25	Under	3–31–31	—— ——	4–3–31	Brown spots, no leaf drop
Spermaceti....	2	Upper	4–2–31	4/15 4/23	None	
Spermaceti....	2	Under	4–2–31	4/15 4/23	None	
Spermaceti....	4	Upper	4–2–31	4/15 4/23	None	
Spermaceti....	4	Under	4–2–31	4/15 4/23	None	
Spermaceti....	25	Upper	3–31–31	—— ——	4–3–31	Brown spots, dead areas in leaves
Spermaceti....	25	Under	3–31–31	—— ——	4–1–31	Brown spots, dead areas, no leaf drop

was done with the purpose of making the wax visible wherever it penetrates. Small drops of wax emulsion, diluted 1:5 with water, were deposited on the upper and under surfaces of apple foliage grown in the greenhouse. Frequent observations were made over a period of six days to determine whether or not the wax had penetrated thru the epidermis. For this purpose the epidermal layer of the leaf area where the wax emulsion was applied was carefully removed and the underlying tissue studied under binocular or low power microscope. Unlike the refined petroleum (3) oils or liquid wax (sperm oil), the solid waxes have shown no penetration when applied either on the upper or lower surface

as was revealed by the absence of red color in the leaf tissue. This should be expected since the waxes, even when emulsified, remain as solid particles in suspension and do not go in solution.

TABLE 2. TESTS WITH WAX EMULSIONS ON PEACH TREES GROWN IN THE GREENHOUSE

Wax used	% wax	Surface of leaf treated	Date sprayed	Spray repeated	Injury observed	Nature of injury
Candelilla	2	Upper	4–2–31	4/15 4/23	None	
Candelilla	2	Under	4–2–31	4/15 4/23	None	
Candelilla	4	Upper	4–2–31	4/15 4/23	None	
Candelilla	4	Under	4–2–31	4/15 4/23	None	
Candeli'la	25	Upper	3–31–31	—— ——	None	
Candelilla	25	Under	3–31–31	—— ——	None	
Paraffin 42° C.	2	Upper	4–2–31	4/15 4/23	None	
Paraffin 42° C.	2	Under	4–2–31	4/15 4/23	None	
Paraffin 42° C.	4	Upper	4–2–31	4/15 4/23	None	
Paraffin 42° C.	4	Under	4–2–31	4/15 4/23	None	
Paraffin 42° C.	25	Upper	3–31–31	—— ——	4–10–31	Slight browning of leaves
Paraffin 42° C.	25	Under	3–31–31	—— ——	4–3–31	100% leaf drop
Paraffin 55° C.	2	Upper	4–2–31	4/15 4/23	None	
Paraffin 55° C.	2	Under	4–2–31	4/15 4/23	None	
Paraffin 55° C.	4	Upper	4–2–31	4/15 4/23	None	
Paraffin 55° C.	4	Under	4–2–31	4/15–4/23	None	
Paraffin 55° C.	25	Upper	3–31–31	—— ——	4–11–31	Very slight browning of leaves
Paraffin 55° C.	25	Under	3–31–31	—— ——	4–3–31	Brown spots and dead leaves
Spermaceti	2	Upper	4–2–31	4/15 4/23	None	
Spermaceti	2	Under	4–2–31	4/15 4/23	None	
Spermaceti	4	Upper	4–2–31	4/15 4/23	None	
Spermaceti	4	Under	4–2–31	4/15 4/23	None	
Spermaceti	25	Upper	3–31–31	—— ——	4–3–31	Brown spots in leaves
Spermaceti	25	Under	3–31–31	—— ——	4–2–31	Heavy leaf drop

THE EFFECT OF WAX EMULSIONS ON PLANTS. In order to determine whether or not these solid waxes are injurious to foliage, peach and apple trees grown in the greenhouse were treated three times successively at intervals of two weeks with wax emulsions containing 2%, 4%, and 25% actual wax. The highest concentration of wax here indicated was too thick to spray and a thin uniform coat of the stock emulsion was deposited on the leaves by the aid of a hair brush.

The results from these sprays, presented in Tables 1 and 2, show that no injury occurred on apple or peach foliage from any one of the four wax emulsions when applied at 2% and 4% of actual wax concentrations. Of the 25% concentration, candelilla wax produced no injury, while each one of the other three waxes formed brown spots on foliage and caused leaf drop. The injury was especially pronounced when the waxes were

applied on the undersurface of the leaves. The concentration of 25% wax was tested with the purpose of determining whether it is at all possible to cause injury to foliage by a heavy coat of wax. For practical spraying, of course, about 0.5% to 1% of wax proved ample to produce a uniform coat over the leaf surface.

FIELD TESTS ON PEACH AND APPLE TREES. In order to substantiate the greenhouse results on the effect of wax emulsions on foliage, peach and apple trees in the orchard were sprayed four times successively at 2-weekly intervals during June, July and the early part of August with wax emulsions containing 0.5%, 1%, and 2% of actual wax. The first spray was applied on June 2, and the last on August 5. No injury whatsoever has been noticed from any one of the four waxes tested. Observation on sticking and spreading properties disclosed the following results.

1. Candelilla wax produced very poor sticking and poor spreading with all the concentrations tested.
2. Paraffin 42° M.P. gave good sticking with the 1% and 2% wax and poor sticking with 0.5% concentration, while the spreading was only fair.
3. Spermaceti wax has shown good spreading properties for all the three concentrations, good sticking with either 1% or 2% spray and only fair sticking with the 0.5% concentration.
4. Paraffin 55° M.P. has shown the best sticking properties of all the four waxes tested, while it was less efficient in its spreading properties than spermaceti and was equal in this respect to paraffin 42° M.P.

In general, the above observations disclosed that candelilla wax possesses poor sticking and very poor spreading properties and was, therefore, entirely excluded from the subsequent tests. The paraffin wax melting at 55°C. has proved to be the best sticker, while spermaceti has given the best spreading properties. The paraffin wax melting at 42°C. ran a middle course between the other two waxes.

LABORATORY TESTS WITH WAX EMULSIONS ON INSECTS. Having ascertained that no injury results to foliage from sprays containing 4% or less of actual wax, the next step was to study the toxicity of these wax emulsions against both sucking and chewing insects, either when applied alone or in combination with other well known insecticides. Apple aphis and silk moth caterpillars were used for these tests.

TESTS ON APHIS. Young apple twigs infested with green aphis (*Aphis pomi* DeGe.) and rosy aphis (*Aphis sorbi* Kalt.) were brought in the laboratory and sprayed with the following solutions.

A. Emulsions of spermaceti, paraffin 42° M.P. and paraffin 55° M.P. containing 1% actual wax.

B. The same solution as in group A, but each one contained pyrethrum extract equivalent to one pound of flowers to a gallon of stock emulsion.

C. Checks consisting of pyrethrum extract and triethanolamine oleate in the same concentrations as those present in A and B.

After the sprays were applied, the twigs were transferred to bottles of water and placed on large sheets of paper, the edges of which were coated with a band of tangle foot. After 24 hours the live and dead aphis were counted and the per cent kill calculated. The aphis which dropped on the paper and crawled into the tangle foot were considered alive. The pyrethrum was incorporated in the form of a kerosene extract in the melted wax before emulsifying.

TABLE 3. TESTS WITH WAX EMULSIONS ON APPLE APHIS

Wax used	Dilution of emulsion	% wax used	Dilution of pyrethrum flowers containing 0.9% pyrethrins	% triethanolamine oleate	Total No. of aphis	% aphis dead after 24 hours
Spermaceti.....	1:25	1.0	None	0.2	1492	51.26
Spermaceti.....	1:25	1.0	1:400	0.2	1519	93.00
Paraffin 42° M.P.	1:25	1.0	None	0.2	1218	40.60
Paraffin 42° M.P.	1:25	1.0	1:400	0.2	1380	82.00
Paraffin 55° M.P.	1:25	1.0	None	0.2	1156	44.30
Paraffin 55° M.P.	1:25	1.0	1:400	0.2	1620	80.90
Check (pyrethrum only)	None	None	1:400	0.2	1050	64.20
Check (tap water).....	None	None	None	0.2	1265	32.40

From the results, see in Table 3, it appears that the three wax emulsions tested possess appreciable toxicity as contact poisons against aphis, spermaceti ranking highest with 51.26% kill against 32.40% of the check. The toxicity of spermaceti emulsion containing pyrethrum was also higher, namely 93.0%, than the two paraffin waxes, which averaged 82.0% and 82.9% kill. Moreover, each one of the three wax emulsions impregnated with pyrethrum gave considerably higher kill than the spray consisting only of pyrethrum and emulsifier. The differences between these three waxes observed may be ascribed to the more efficient spreading properties of the spermaceti wax emulsion.

TESTS ON CATERPILLERS. The tests on silk moth caterpillars (*Bombyx mori* Linn.) were carried out in the following manner. Mulberry twigs were sprayed with the desired solutions and placed in vials of water under cages. As soon as the leaves were dry, twenty caterpillars in the third or fourth instar were transferred into the cages on the foliage, three or more cages being used for each test. After 72 hours the number of dead and living caterpillars were counted.

TABLE 4. TESTS WITH WAX EMULSIONS ON SILK MOTH CATERPILLARS APPLIED AS STOMACH POISON

Wax used	Dilution of emulsion	Per cent wax sprayed	Dilution of pyrethrum flowers containing 0.9 per cent pyrethrins	Dilution of derris root containing 4 per cent rotenone	Percent triethanolamine oleate emulsifier	Total No. of caterpillars	Per cent dead after 72 hours
Spermaceti	1:25	1.0	None	None	0.2	60	4.0
Spermaceti	1:25	1.0	1:400	None	0.2	60	42.0
Spermaceti	1:25	1.0	None	1:400	0.2	60	96.0
Paraffin 42° M.P	1:25	1.0	None	None	0.2	60	0.0
Paraffin 42° M.P	1:25	1.0	1:400	None	0.2	60	44.0
Paraffin 42° M.P	1:25	1.0	None	1:400	0.2	60	95.0
Paraffin 55° M.P	1:25	1.0	None	None	0.2	60	0.0
Paraffin 55° M.P	1:25	1.0	1:400	None	0.2	60	43.00
Paraffin 55° M.P	1:25	1.0	None	1:400	0.2	60	100.0
Check (pyrethrum)	None	None	1:400	None	0.2	80	35.0
Check (derris only)	None	None	None	1:400	0.2	100	90.0
Check (tap water)	None	None	None	None	0.2	80	0.0

The spray solutions consisted of the following:

A. Dilute emulsions of the three waxes containing 1% actual wax.

B. The same solutions as in A but each one contained pyrethrum extract equivalent to one pound of flowers to a gallon of stock emulsion.

C. The same solution as in A but each one contained derris extract equivalent to one pound of derris root to a gallon of stock emulsion.

D. Checks, consisting of pyrethrum and derris solutions with no wax.

Each solution, of course, contained the same amount of triethanolamine oleate emulsifier. The derris extract, on account of its low solubility in waxes, was added to the dilute solutions just before spraying. The root analyzed about four per cent rotenone.

The results from these tests, presented in Table 4, show that none of the three waxes possess any direct toxicity as a stomach poison. In combination with either pyrethrum or derris extracts the waxes increased somewhat the toxicity of the latter two products. It is of interest to note here that wherever derris extract was used either alone or in combination with the waxes very high kill of caterpillars was obtained, ranging from 90 to 100%. The pyrethrum extract, whether used alone or in combination with the waxes, lagged considerably behind derris, ranging from 35 to 44% kill. The slight increase in toxicity of both pyrethrum and derris extract brought about by the wax emulsions may be due to a more uniform coverage of spray material.

Summary and Conclusions

Greenhouse and orchard experiments with solid waxes of vegetable, animal, and mineral origins were carried out with the purpose of studying their insecticidal properties as well as their efficiency as carriers for arsenical substitutes. The waxes were emulsified by the aid of triethanolamine oleate. Wax emulsions alone and impregnated with extracts of pyrethrum flowers and derris root were tested on apple aphis and silk moth caterpillars.

1. Emulsions of the following waxes produced no injury to apple and peach foliage: spermaceti, candelilla, and paraffin in concentrations of 4% or lower of actual wax content.

2. Emulsions containing 1% wax possess appreciable toxicity as contact insecticides and practically no toxicity as internal insecticides.

3. When impregnated with either pyrethrum or derris extracts, emulsions containing 1% wax possess high toxicity to both, sucking and chewing insects.

REFERENCES

1. BACON, R. F., and HAMOR, W. A. The American Petroleum Industry. McGraw-Hill. New York.
2. GINSBURG, J. M. 1930. What Summer Oil Sprays May do to Apple Trees. Journal of Economic Entomology, Vol. 24, No. 1, p. 284.
3. GINSBURG, J. M. 1931. Penetration of Petroleum Oils into Plant Tissue. Journal of Agricultural Research, Vol. 43, No. 5, p. 469.
4. GRUSE, W. A. 1928. Petroleum and Its Products. McGraw-Hill. New York.
5. HEADLEE, T. J., GINSBURG, J. M., and R. S. FILMER. 1930. Some Substitutes for Arsenic in Control of Codling Moth. Journal of Economic Entomology, Vol. 23, No. 1, p. 45.
6. LEONARD, M. D. 1930. Further Experiments with Nicotine Oil for the Control of the Codling Moth in the Pacific North West. Journal of Economic Entomology, Vol. 23, No. 1, p 61.
7. LEWKOWITSCH, J. 1914. Chemical Technology and Analysis of Oils, Fats, and Waxes. Macmillan and Company, London.
8. SPULER, A. 1929. Spraying Experiments for Codling Moth Control. Washington Agricultural Experiment Station, Bulletin 232.

EXPERIMENTS WITH TAR DISTILLATE SPRAYS

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ABSTRACT

A number of brands of tar washes and a home-made emulsion of American creosote oil were investigated as regards their constitution, effects on insects and toxicity to trees. The chemical constitution as regards distillation range, acid content, and types of washes are briefly discussed. At the proper dilutions these emulsions seem to be effective against rosy aphis, oystershell scale, San Jose scale, and pear psylla; also, they were reasonably efficient against the eye-spot bud moth. They did not seem to give any control against plum curculio, apple seed chalcid, apple leafroller, *pomaria* leafhopper of the apple, and had only a slight effect upon apple red bugs. While no permanent injury was observed to apple trees, mixtures containing more than 8 per cent of tar oils were generally quite destructive to swelling buds even tho they had not reached the silver-tip stage. Mixtures containing less than 8 per cent tar oils varied in destructiveness to buds according to dilution and variety of apple, but in no instance was the damage severe as regards the set of fruit. A 4 per cent mixture did not injure the swollen buds of pear or peach in limited tests. Mixtures of tar oils and lubricating oils proved very toxic to apple buds. The practicability of these washes for orchard use are discussed.

As previously reported, investigations with tar distillate sprays have been in progress for several years.[1] The scope of the field tests during 1931 was broadened in six ways: (1) The number of duplicate trials was increased, which also included more commercial varieties of apples

[1]Jour. Econ. Ent. 24:297–302. 1931.

together with some spraying of pears and peaches; (2) the experiments included field tests on the following insects: rosy aphis (*Anuraphis roseus*), apple red bugs (*Heterocordylus malinus* and *Lygidea mendax*), buffalo treehopper (*Ceresa bubalus*), a species of leafhopper attacking apples (*Typhlocyba pomaria*), San Jose scale (*Aspidiotus perniciosus*), eye-spot bud moth (*Spilonota ocellana*), fruit-tree leafroller (*Cacoecia argyrospila*), and pear psylla (*Psyllia pyricola*). In these efforts opportunity was also afforded to secure data and to make observations as regards the effect of tar washes on the following additional species: oyster-shell scale (*Lepidosaphes ulmi*), codling moth (*Carpocapsa pomonella*), apple seed chalcid (*Syntomaspis druparum*), and plum curculio (*Conotrachelus nenuphar*); (3) a larger number of brands were tested than in previous seasons; (4) field operations included several fruit areas of western New York and the Hudson valley; (5) combinations containing tar distillate emulsions and petroleum oil emulsions were tried; (6) chemical and physical studies of the various mixtures have been under way to determine how these properties are related to insecticidal values and toxicity to trees.

Some of the investigations mentioned were conducted by other members of the department, the results of which are not included in this paper. In fact, only a partial report of the results secured by the authors can be given owing to limitations of space. These may be arranged for the purpose of discussion in several groups; namely, chemical studies, results on insects, effect on trees, and practical considerations.

Chemical Studies. The active ingredients of tar distillate washes are certain oils which are produced by distillation of coal tar. The American creosote oil under experiment included all the fractions distilling from 200°C. to about 360° C. It is a black, tarry, somewhat viscous liquid with the characteristic odor of creosote, and has an acid content of about 10 per cent. The creosote oil was emulsified by means of turkey red oil (sulfonated castor oil) and sodium hydroxide.

Some of the commercial brands used in the experiments contained tar oil similar to those recommended for making the Long Ashton wash. These oils distil between 270° and 360° C. and have had most of the tar acids removed. Other brands consisted of similar oils but had a higher tar acid content; while other kinds appear to have been manufactured from American creosote oil having a tar acid content of between 15 and 18 per cent. It should be stated that two tar distillates having boiling points between 270° and 360° may differ considerably in the amounts that distil between certain narrower temperature limits. The brands are sold under two forms: one-solution and two-solution washes.

The one-solution brands are stock emulsions or miscible oils and require merely agitation and the proper dilution with water to make a spray mixture. The two-solution washes contain an emulsifying agent (usually a sulfonated oil) dissolved in the tar oils. In order to produce an emulsion the desired amount of stock material is placed in the spray tank with a small amount of water to which is added a definite amount of caustic soda solution. The proportion and strength of the soda solution are specified by the manufacturer.

RESULTS ON INSECTS. As is well known, these emulsions are intended for use while the trees are dormant. On the British Isles and on the Continent temperatures generally are sufficiently high to permit winter applications. Under western New York conditions, on the other hand, the apple will frequently retain its foliage until severe cold weather arrives, thus precluding late autumn or early winter treatment. Also, there is usually little opportunity to make true winter applications owing to continued cold weather, so reliance is placed on late winter or early spring spraying. The dates for treatment in the Station orchard were March 20, 1930, and March 26 and 27, 1931. In the latter year the buds of Rome Beauty had started to swell but had not reached the silver-tip stage. In commercial plantings the materials were applied at the silver-tip stage with the exception of one orchard where the buds were just swelling. Greenings, in one instance, were in the green-tip stage, while Baldwins adjoining were in silver-tip.

In the Station orchard the amount of material per tree was somewhat greater than in commercial plantings. In the latter the treatment would be classed by growers as good commercial applications. In other words, the trees were not drenched excessively. The results in a Station apple orchard, in three private apple orchards, and in one commercial pear orchard are discussed.

At the Station lime-sulfur and nicotine sulfate applied at the delayed dormant gave an efficiency of 99 per cent on rosy aphis. American creosote oil (10 per cent) emulsified in the spray tank showed an efficiency of 90 per cent; Solignum New Long Ashton Wash (10 per cent) 96.5 per cent control. Barko (12½ per cent and 6¼ per cent) each gave an efficiency of 97 per cent. The red bug infestation in this planting was insignificant.

In two commercial orchards where aphis was present in light to moderate numbers Barko (5 per cent) gave efficiencies of 88 to 90 per cent; while in one planting Barko (10 per cent) produced an efficiency of only 15 per cent, a result largely due to excessive wood in the trees. Against apple red bugs the tar distillate emulsion gave very poor results. In two orchards Barko (5 per cent) gave efficiencies of 0 and 19 per cent respec-

tively, while Barko (7½ per cent) gave efficiencies of 0 and 22 per cent. Even a 10 per cent emulsion of Barko in one orchard gave efficiencies of 0 on both McIntosh and Baldwin against red bug. All the above results are based on counts of picked fruit.

In the case of the eye-spot bud moth the data was taken during June when the feeding of the overwintering larvae was conspicuous by the webbing together of the terminal leaves. Since each cluster is usually produced by a single larva the number present on the lower part of a tree can be rather easily counted. In the orchard where the bud-moth experiments were made the trees had the lower limbs reaching to the ground, so a good index of the population per tree was secured by examining all the branches to a height of about seven feet. Barko (10 per cent) gave efficiencies of 84 per cent on Baldwin and 75 per cent on McIntosh. Barko (7½ per cent) gave the following efficiencies on the several varieties: Twenty-ounce, 77 per cent; Greening, 75 per cent; and McIntosh, 64 per cent. Barko (5 per cent) gave the following efficiences: Greening, 57 per cent; Twenty-ounce, 37 per cent; and McIntosh, 33 per cent. Barko (5 per cent) with one pint of nicotine sulfate in 100 gallons showed 67 per cent control on Greening, while Diamond Paraffin oil 8 per cent gave an efficiency of 43 per cent; and Diamond paraffin oil 8 gallons and nicotine sulfate 1 pint in 100 gallons of mixture gave a control of 55 per cent. The check trees on the several varieties had the following number of larvae: Greening 294; Baldwin 269; Twenty-ounce 172; and McIntosh 169.

In the Station orchard the check plat became moderately infested with San Jose scale due to omission of lime-sulfur sprays over a period of years. All of the trees except one were given a treatment of lubricating oil emulsion (3 per cent oil), and one tree was sprayed with Solignum New Long Ashton Tar Wash (10 per cent). From the amount of scale injury on the fruit the tar wash gave practically as good results as did the petroleum oil.

In one of the private orchards a tree was very severely infested with oyster-shell scale. This was sprayed with Barko (7½ per cent), and later observations showed that the eggs were discolored and that very few hatched. Examinations in the fall revealed an almost complete absence of oyster-shell scale of the 1931 brood as well as a thoro cleaning of old forms from the bark.

In no instance did any of the tar distillates control apple leafroller.

At the time when the semi-dormant oil sprays were made for pear psylla a number of pear trees were treated with Solignum Dormoil[2]

[2]Dormoil consists of certain fractions of tar oil and petroleum intimately mixed and emulsified.

(5 per cent) and this gave an efficiency of 92 per cent on pear psylla. An adjoining block was treated the same day with lubricating oil emulsion (3 per cent oil) and this gave a control of 98 per cent.

From the above data it will be seen that the tar washes generally gave good control of rosy aphis, altho not so high an efficiency as lime-sulfur and nicotine sulfate in 1931. It should be noted that in 1930 the tar washes, altho giving about the same average efficiency, proved to be considerably more effective than lime-sulfur and nicotine sulfate against rosy aphis. The difference is explained by the fact that in 1930 the weather was exceptionally unfavorable for making thoro and timely applications of nicotine sprays, while in 1931 conditions were very favorable as regards the same. The tar washes appear to have given good commercial control of bud moth and San Jose scale, and excellent control of oystershell scale. However, they seem to have entirely failed to control apple leafroller, plum curculio and apple seed chalcid, and had little effect on the Pomaria leafhopper of apple, and apple red bug. The results on pear psylla can perhaps be classed as commercial control, altho further experimentation is necessary before conclusions should be drawn.

Effect on Trees. Unless specified, all references to trees apply to the apple. The concentration of the tar washes, based on the actual amount of distillate, varied from 4 to 10 per cent. As stated above, none of the applications were made when the trees were strictly dormant, but were made in most instances as soon as field and weather conditions permitted. There was some swelling of the buds on the earliest treated apple trees, while of those treated latest some varieties, such as Greening, showed many buds in the green-tip stage. Some scorching of the first leaves occurred on practically all the treated trees, but was most pronounced with the heavier concentrations, In general, little injury occurred to the fruit buds except that in the case of Twenty-ounce and Baldwin treated in the silver-tip stage with 8 per cent actual tar oil a considerable number of buds were killed. With some brands a concentration of 10 per cent tar oil caused very severe injury to the buds. Here again, considerable variation was observed on different varieties. To date no permanent injury to the trees has been observed.

When the spray mixture contained 2.5 per cent of tar distillate and 4 per cent of lubricating oil the injury to the buds was quite severe on the variety Wealthy, but only moderately severe injury occurred on most varieties. A mixture containing about 6.5 per cent of tar oil and 8 per cent of lubricating oil proved very toxic to leaf and fruit buds of all varieties used in the test. In some instances practically all the primary buds were destroyed.

Secondary buds developed, and by mid-summer the effects of the early injury had disappeared except, of course, that there was no fruit on trees which had a very heavy set of fruit buds previous to treatment. Branches were uninjured but many twigs died the following winter. Workers in the British Isles have been testing mixtures of tar distillates and petroleum oils with the object of developing a type of insecticide that would be effective against a larger range of fruit pests. However, little has been mentioned as regards injury. All the writers' tests with such combinations and with brands not previously tested under New York conditions were made on trees in portions of the Station orchards where severe injury or death of the trees would not affect other experiments. Unfortunately, most of these trees were not seriously infested. In fact, the object was to determine the safety factor of the materials so that the promising ones could be tested either in the more permanent Station plantings or in commercial orchards. Under western New York conditions, therefore, it would appear that sprays containing more than 8 per cent of actual tar distillate are quite liable to be injurious to apple buds when sprayed after they have swelled; that mixtures containing 8 per cent tar oils are reasonably safe on some varieties but may injure the buds of other kinds; that sprays containing 5 per cent or less of the tar distillate are usually quite safe; and that mixtures of tar washes and lubricating oil emulsions need further field tests to determine safe dilutions. Dormoil (5 per cent) did not prove injurious to the swollen buds of Beurre Bosc pears nor to semi-dormant peach buds. However, these results need to be confirmed by further tests before any definite conclusions can be drawn relative to the safety of these mixtures on pear and peach.

Practical Considerations. The Station experiments for the past two seasons show that the tar distillate washes are practically as effective as nicotine sprays against rosy aphis, and one season's results indicate that they may be as effective against bud moth and oyster shell scale as any known treatment. These washes were reasonably effective against San Jose scale and pear psylla. Against a number of other apple pests they have either not proven effective or, at the present stage, seem to lack somewhat in reaching an efficiency equal to other methods of treatment. At present tar washes cost from two to three times as much as nicotine for aphis control. However, some commercial growers with large acreages believe that the cost is not prohibitive if the treatment is safe on trees in view of the fact that it prolongs the period over which spraying is effective against this pest. In other words, a portion of the area can be treated with tar wash and the remainder with nicotine,

thus enabling the fruitgrower to select the better weather conditions for making the application and thereby increase the chances for effective control. It is obvious that reduction in the cost per tree, without losing effectiveness, will add to the popularity of tar washes for rosy aphis treatment.

The caustic action of tar washes to the skin should be mentioned. Some workers suffer rather severe burning due to spattering of the spray or drifting mist. No preventive has been discovered, but it is hoped that some method of avoiding the unpleasant experiences will be found. Vaseline has been tried, but proved useless. It is advisable to spray with the wind to avoid wetting of the skin and to protect the hands by means of gloves.

THE EFFICIENCY OF TAR DISTILLATE SPRAYS IN CONTROLLING SAN JOSE AND SCURFY SCALES IN 1931

By W. S. HOUGH, *Virginia Agricultural Experiment Station*

ABSTRACT

Results of one season's orchard experiments with five coal tar distillate sprays or "washes" for the control of San Jose scale indicate that, (1) only the higher concentrations (1–10 and possibly 1–15) may give control somewhat comparable to that obtained with a standard petroleum oil emulsion of 3% oil, (2) some tar distillates were more efficient than others having about the same boiling range. Tar distillate sprays at concentrations of 1–10 and 1–15 were fairly promising against scurfy scale.

According to Parker (1) tar distillate washes had their origin in German carbolineum which contained coal tar distillates as the base and was originally used as a wood preservative. During the past nine years much attention, especially in England, has been given to the study of the insecticidal value of the various tar distillates. It has been pointed out (2) that there is considerable difference in the composition of the creosotes according to the class of coal used and the technique of distillation. The varying composition of tar oils is perhaps the chief factor causing the more or less variable results reported in insecticidal tests. During recent years, however, experimental data indicates that the tar distillate sprays are highly effective in killing eggs of some insects, including aphids, the apple psylla and certain Lepidoptera.

Although tar oil was used at least ten years ago in Europe (3 and 4) as a constituent of insecticides against scale insects, there is comparatively little recorded on the value of the more recent tar distillate

washes against Coccids infesting fruit trees. Jones (5) and Theobald (6) found tar oil sprays effective against oyster shell scale (*Lepidosaphes ulmi* L.). Several investigators including Theobald (6) and Vukasovic (7) report effective control of *Lecanium* scales on apple and plum respectively. Bondarev (8) used 20% tar distillate against *Lecanium* scales and *Aspidiotus ostraeformis* Curt. on cherry.

During the past two years tar distillate sprays have been used in orchard experiments against the hibernating larvae of the pistol casebearer (*Coleophora malivorella* Riley) and eggs of apple aphids (*Anuraphis roseus* Baker, *Rhopalosiphum prunifoliae* Fitch and *Aphis pomi* DeG.). Against the eggs of aphids the results have been quite favorable. Since scale insects must be controlled in Virginia apple orchards in the dormant season, it seemed highly desirable to seek information on the value of the tar distillates against San Jose scale (*Aspidiotus perniciosus* Comstock) especially.

Four of the five tar distillates used were of English origin and were of the miscible type. The creosote oil used in the material which I have designated as "tar distillate emulsion" came from Pittsburg and was emulsified according to two formulae developed by R. H. Hurt of the Virginia Experiment Station. All preparations mixed readily with hard water.

Applications were made on apple trees on favorable days during the dormant season. The temperature ranged from 40° to 58° F. when the sprays were applied in November, February and March. The April applications were made at temperatures ranging from 70° to 77° F., and after the first green leaves were showing in the buds. In order to avoid excessive injury, the April sprays were applied with a hand sprayer and only the scale-infested twigs and bark on limited parts of the trees were sprayed.

No visible injury followed the use of tar distillates on any of the trees sprayed in the dormant season, except in one orchard where about 125 York Imperial trees (20 years of age) were sprayed on March 18. Although this day was ideal for spraying (clear and temperature of 52° F.) and the buds did not show the first bit of green until two weeks later, the development of foliage was retarded to a marked degree through April. Some of the buds on the lower limbs were killed. Tar distillate spray was used at the rate of 5 and 6 gallons in 100 gallons of spray mixture in this orchard.

Examination of San Jose scale was made from April 10 to 21 for trees sprayed in November and February and May 12 to 16 for trees

sprayed in April. The results are recorded in Table 1. The per cent of control is calculated according to the formula given by Abbott (9). The control obtained by two petroleum oil emulsions is given for comparison.

TABLE 1. RESULTS OF EXPERIMENTS ON CONTROL OF SAN JOSE SCALE ON APPLE TREES, WINCHESTER, VIRGINIA, 1931

Date sprayed	Material used and amount in 100 gallons of spray mixture	No. of scales— Examined	Alive	Per cent— Alive	Control
1930	Shenandoah Vinegar Co. orchard				
Nov. 24	Tar distillate "Barko" 10 gallons	1,000	28	2.8	89
Nov. 24	Tar distillate "Barko" 6⅔ gallons	1,000	23	2.3	91
Nov. 24	Tar distillate "Barko" 5 gallons	1,000	76	7.6	70
	Check, not sprayed	1,000	262	26.2	—
1930	Richard's orchard				
Nov. 24	Tar distillate "Barko" 10 gallons	1,100	0	0.0	100
Nov. 24	Tar distillate "Barko" 6⅔ gallons	1,100	0	0.0	100
Nov. 24	Tar distillate "Barko" 5 gallons	1,100	46	4.1	83
1931					
Feb. 4	Tar distillate "Barko" 10 gallons	1,000	21	2.1	91
Feb. 4	Tar distillate "Barko" 5 gallons	1,000	110	11.0	54
Feb. 4	Tar distillate emulsion 10 gallons	1,000	39	3.9	83
Feb. 4	Tar distillate emulsion 6⅔ gallons	1,000	133	13.3	46
Feb. 4	Tar distillate emulsion 5 gallons	1,000	178	17.8	25
Feb. 4	Petroleum oil emulsion (3% oil)	1,000	10	1.0	96
Feb. 4	Petroleum oil emulsion (2% oil)	1,000	17	1.7	92
	Check, not sprayed	1,000	241	24.1	—
1931	Bailey's orchard				
Feb. 24	Tar distillate emulsion 10 gallons	1,000	112	11.2	79
Feb. 24	Tar distillate emulsion 6⅔ gallons	1,000	265	26.5	51
Feb. 24	Tar distillate emulsion 5 gallons	1,000	427	42.7	21
Apr. 16	Tar distillate "Ovicide" 10 gallons	1,000	2	0.2	99
April 16	Tar distillate "Ovicide" 6⅔ gallons	1,000	18	1.8	96
Apr. 16	Tar distillate "Ovicide" 5 gallons	1,000	142	14.2	74
Apr. 17	Petroleum oil emulsion (3% oil)	1,000	15	1.5	97
Apr. 18	"Long Ashton Neutral Tar Wash" 6⅔ gal	1,000	56	5.6	89
Apr. 18	"Metro Neutral Tar Wash" 6⅔ gallons	1,000	102	10.2	81
	Check, not sprayed	2,000	1089	54.4	—

From the results obtained it appears that certain tar distillates possess insecticidal properties against San Jose scale. It is evident, however, that comparable dilutions of the various distillates gave variable results and that only the higher concentrations of any of the tar oils resulted in control comparable to that obtained with the two petroleum oil emulsions at 3% strength.

The trees sprayed for the control of the scurfy scale (*Chionaspis furfura* Fitch) were examined on May 18. At this date hatching of the eggs had been completed, although many of the young were still beneath the scales. All empty egg shells were considered as hatched while the unhatched eggs were shriveled. The results are given in Table 2. It ap-

peared to the writer that incomplete coverage of some of the scales might account for the failure to obtain 100% control in all three plots.

TABLE 2. RESULTS OF EXPERIMENTS ON CONTROL OF SCURFY SCALE ON APPLE TREES, WINCHESTER, VIRGINIA, 1931

Date sprayed	Material used and amount in 100 gallons of spray mixture	No. of eggs— Examined	Hatched	Per cent— Hatched	Control
Mar. 25	Tar distillate "Barko" 10 gallons..	1,062	23	2.1	97
Mar. 25	Tar distillate "Barko" 6⅔ gallons.	1,111	78	7.0	92
Mar. 25	Tar distillate emulsion 6⅔ gallons	890	0	0.0	100
	Check, not sprayed.....	1,045	958	91.6	—

The results are not considered conclusive but are perhaps suggestive of the insecticidal efficiency of coal tar distillate against armored scales. Variable composition of the tar oil fractions is also suggested by the variable results against San Jose scale. Except for the neutral tar oils applied on April 18, each of the tar oils used was reported to have nearly the same distillation range (215°–360° C.) and the tar acid content averaged 10% (reported 8% to 12%). In this connection it is recalled that the work of Tutin (10) and subsequent investigations in England indicate that the tar distillate boiling above 280° C. is more toxic than the lower boiling fractions or the total distillate, and that the presence of tar acids lowers the toxicity of the high boiling fractions.

The future of tar distillate sprays in this country cannot be forecast, but it is likely that sprays of this type will have to be used at such dilutions as to bring them within the cost range of our present petroleum oil emulsions, provided, both can be used with equal effectiveness against Coccids and other insects in the dormant season. For the control of both scale insects and aphids on fruit trees in the dormant season a combination spray of coal tar distillate and petroleum oil may eventually be practical.

REFERENCES

1. PARKER, T. Tar oil emulsions. F. B. G. Journal of the Federated British Growers, Vol. 3, No. 12, pp. 111–112, London, Dec. 1924.
2. PARKER, T. Emulsified oils for the destruction of insect eggs. Gardeners' Chronicle, Vol. 81, Nos. 2090–2091, pp. 54 and 72, Jan. 1927.
3. JANINI JANINI, R. The chief diseases and pests of the orange and lemon groves of Spain, Internatl. Rev. Sci. and Pract. Agric. N. S. Vol. 1, No. 1, pp. 61–73, Rome, Jan.–Mar. 1923.
4. PAILLOT, A. Le traitement d'hiver des arbres fruitiers. Cultures Fruitiers, Vol. 2, No. 9, pp. 161–162, Paris, Jan. 1924.
5. JONES, H. L. Winter spraying of fruit trees with carbolineum washes. Welsh. Jour. Agric., Vol. 3, pp. 298–302, Cardiff, Jan. 1927.
6. THEOBALD, F. V. Tar distillate trials in Kent and West Sussex in 1928. Jour. Pomol. and Hort. Sci., Vol. 7, No. 3, pp. 199–211, London, Dec. 1928.

7. VUKASOVIC, P. Observations on *Lecanium corni* on plums. (In Serbian) Glasnik Tzentr. Khig. Zavoda, Vol. 6, Nos. 10–12, Belgrade, 1928. (Abstract in Rev. Appl. Ent. Vol. 17, p. 209, Apr. 1929.)
8. BONDAREV, O. A. V. Contact insecticides and Coccidae. (In Ukrainian) Mleev Hort. Exp. Sta. Bull. No. 29, Mleev, 1930. (Abstract in Rev. Appl. Ent. Vol. 19, p. 175, Mar. 1931.)
9. ABBOTT, W. S. A method of computing the effectiveness of an insecticide. Jour. Econ. Ent. Vol. 18, No. 2, pp. 265–267, Apr. 1925.
10. TUTIN, F. Investigations on tar distillate and other spray liquids. Rept. Agric. Hortic. Research Station (Long Ashton) Bristol, pp. 81–90, 1927.

THE MEXICAN BEAN BEETLE IN CONNECTICUT

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ABSTRACT

Distribution, life history studies, host selection and control measures of *Epilachna corrupta* are discussed.

The Mexican bean beetle, *Epilachna corrupta* Muls., was discovered in Connecticut by Dr. E. P. Felt, who reported its presence in Stamford in July, 1929. During that year, the beetle was reported from 17 towns in the western half of the State. In 1930, it was reported from other towns in all parts of the State, and some damage was done by the second generation in several localities. In 1931, the distribution included the entire State and serious injury was noted in many places. The first generation was destructive in Fairfield and New Haven Counties, and the second generation caused damage in all parts of the State.

TABLE 1. AVERAGES OF REARINGS

Date started	Incubation period	First instar	Second instar	Third instar	Fourth instar*	Pupal period	Total
1st generation							
June 20.....	8	6	3	4	7	7	35
July 5.....	8	5	3	3	7	7	33
2nd generation							
July 30.....	7	5	3	4	8	9	36
July 31.....	8	5	3	5	7	9	37
Aug. 5.....	8	4	4	4	9	8	37
Aug 10.....	8	6	2	5	9	9	39

*Includes prepupal period.

LIFE HISTORY. The Mexican bean beetle had two complete generations in Connecticut during 1931. Eggs were found in the field on June 9, and the first generation adults started emerging on July 10. Second generation eggs were found July 25, and second generation adults started emerging September 1. Eggs were found in the field as late as September 24. In the insectary cages, first generation adults deposited eggs un-

til September 29. Third generation eggs were deposited between September 5 and 20. None of these eggs produced adults before frost.

TABLE 2

Host	Date	Number started	Number matured	Larval period* Number	Days	Mean larval period
Phaseolus vulgaris						
Crackerjack wax	July 31	10	8	3	18	
				3	19	18.9
				2	20	
	Aug. 5	30	28	22	21	
				6	22	21.6
	Aug. 10	20	18	5	21	
				10	22	22.0
				2	23	
				1	25	
Mammoth Horticultural	July 30	15	11	4	18	
				4	19	18.9
				3	20	
Bountiful Green Pod	July 31	15	13	2	18	
				4	19	19.5
				6	20	
				1	21	
Navy	July 30	15	13	1	18	
				12	19	18.9
P. coccineus						
Scarlet Runner	July 31	15	9	1	18	
				4	19	19.3
				4	20	
P. lunatus						
Burpee bush lima	July 31	15	10	5	18	
				4	19	18.8
				1	22	
Sieva lima	July 30	15	13	6	19	
				5	20	19.7
				2	21	
Vigna sinensis						
Clay cowpea	July 30	15	10	3	20	
				4	21	21.1
				2	22	
				1	23	
Dolichos lablab						
	July 29	15	0	2	27	27.7
	Aug. 8	12	3	1	29	

*Including prepupal period.

The two generations were rather sharply defined, and there was no evidence that any first generation adults survived until hibernation. One overwintering beetle lived in a cage until August 28, depositing eggs until July 8. In the field, practically all overwintering adults had disappeared before the first generation matured.

The time required from egg to adult is given in Table 1.

The shortest time required by an individual insect was 32 days for a late first generation individual and the longest was 41 days for a second generation individual. The time was greatly influenced by weather conditions.

DURATION OF LARVAL PERIOD ON LEGUMES. In laboratory studies of the first generation host selection, some differences in duration of larval period on various legumes were noted. These differences were checked on second generation larvae, and the results are presented in Table 2. The larvae were reared individually on potted plants.

Reference to Table 2 shows no essential difference in duration of the larval period except in the case of cowpeas and *Dolichos lablab*. Larvae required more than one day longer on cowpeas than on garden beans. In the case of *Dolichos lablab*, only three of 27 newly-hatched larvae matured, and these took eight days longer than larvae on any other legumes.

HOST SELECTION. Small test plots of several legumes were planted to determine host preference. The following rough classification shows the results, the items in the first two groups being listed in the order of preference:

COMMON NAME	SCIENTIFIC NAME
SEVERELY INJURED	
Garden bean (all varieties)	*Phaseolus vulgaris*
Scarlet runner	*P. coccineus*
Lima bean (all varieties)	*P. lunatus*
SLIGHTLY INJURED	
Hyacinth bean	*Dolichos lablab*
Cowpea	*Vigna sinensis*
Yard long bean	*Dolichos sesquipedalis*
Soy bean	*Glycine max*
IMMUNE	
Lentil	*Lens esculenta*
Broad Windsor	*Vicia faba*
Mung bean	*Phaseolus aureus*
Velvet bean	*Styolobium deeringianum*

The Broad Windsor bean is the only immune variety grown in Connecticut.

CONTROL MEASURES. Tests were made against second generation larvae using the following materials:

(1). Spray—Magnesium arsenate	2	lbs.
Casein lime	3	lbs.
Water	100	gals.
(2). Dust—Magnesium arsenate	1	part
Hydrated lime	6	parts
(3). Dust—Barium fluosilicate	1	part
Hydrated lime	6	parts

All of these treatments were applied four times during August to late string and lima beans. All treatments were successful in controlling the Mexican bean beetle, and no burning of foliage resulted from any of them. The spray treatment protected the plants longer than either of the dusts. There was no apparent difference between the arsenical dust and the fluosilicate dust except a slight difference in yield in favor of the magnesium arsenate. This was not necessarily significant, as the experiment was not run accurately enough for such comparisons.

Growers used calcium arsenate both as a spray and as a dust with good results. They also used proprietary dusts containing copper, lime and lead or calcium arsenate with good results. Lead arsenate was used alone and with lime and in Bordeaux mixture by some growers. In a majority of cases, injury resulted.

SUMMARY

The Mexican bean beetle is well established throughout Connecticut.

Two complete generations appeared in the State during 1931.

The first generation required an average time of 33 to 35 days for egg to adult development. The second generation averaged from 36 to 39 days.

Larval development on cowpeas and *Dolichos lablab* was considerably slower than on other host plants.

The common varieties of beans were seriously injured. The Broad Windsor bean is the only immune variety grown in Connecticut.

Magnesium arsenate as a spray was the most satisfactory control. This material and barium fluosilicate used as dusts were equally effective.

TESTS WITH ARSENICALS ON BEANS FOR THE CONTROL OF THE MEXICAN BEAN BEETLE

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ABSTRACT

An attempt is made to appraise the comparative value of a few of the arsenicals when used in spray and dust mixtures for the control of the Mexican bean beetle (*Epilachna corrupta*), as indicated by the comparative safety wherewith such mixtures may be applied to beans. Magnesium arsenate and basic lead arsenate gave the most reliable results, but for eastern growers these arsenicals are comparatively expensive and are not readily procurable. Tests with calcium arsenate, which is comparatively cheap and easily procurable, showed that this insecticide might be used with comparative safety when combined with a copper-lime dust, bordeaux mixture, or a heavy hydrated lime spray.

During 1931 field tests were made on Long Island for the purpose of comparing the safety wherewith various arsenicals might be used in spray and dust mixtures for the control of the Mexican bean beetle.[1] Owing to the relative high cost of many of the more reliable arsenicals special emphasis was placed on the use of calcium arsenate (one brand only) in combination with hydrated lime spray mixtures in an effort to provide a satisfactory cheap mixture for general use.

The arsenicals tested showed the following analyses:

Acid lead arsenate
Total arsenic pentoxide (As_2O_5) 30.0%
Arsenic in water soluble form, expressed as metallic arsenic, not more than .. .5%

Basic lead arsenate
Total arsenic pentoxide (As_2O_5) 20.0%
Arsenic in water soluble form, expressed as metallic arsenic ..... trace

Calcium arsenate
Total arsenic pentoxide (As_2O_5) 40.0%
Arsenic in water soluble form, expressed as metallic arsenic, not more than .. .5%

Zinc arsenite
Total arsenious oxide (As_2O_4) 40.0%
Arsenic in water soluble form, expressed as arsenious oxide ..... .75%

Magnesium arsenate
Total arsenic pentoxide (As_2O_5) 32.0%
Arsenic in water soluble form, expressed as metallic arsenic, not more than .. .23%

TESTS ON LIMA BEANS. Bush lima beans were sown on June 3 in six series of plats, each of which consisted of fourteen 33-foot rows. Seven of these rows in each series were devoted to the testing of various arsenicals, five being treated and two left as checks.

Each series was sprayed or dusted with a basic preparation which served as a sticker or distributor for the poison, except of course in the case of the untreated check rows. Series 1 was sprayed with kayso-water, series 2 with goulac[2]-water, series 3 with bordeaux mixture, series 4 was dusted with copper-lime mixture, series 5 with hydrated lime when the leaves were moist, series 6 with hydrated lime when the leaves were dry.

Six applications were made, namely on July 3–4, July 16, August 5, August 10–11, August 15, 17, and on September 4 respectively. The spray mixtures were applied by hand at the average rate of 200 gallons per acre, and the dust mixtures by hand at the average rate of 40 pounds per acre.

[1] *Epilachna corrupta* Muls.

[2] Powdered lignin pitch.

TABLE 1. THE COMPARATIVE WEIGHTS OF PODS AND VINES OF BEANS SPRAYED SIX TIMES WITH ARSENICAL MIXTURES

Arsenical ingredient	Weight of pods per row, Spray mixture				Average weight per plant, Spray mixture			
	Kayso-water	Goulac-water	Bordeaux mixture	Average	Kayso-water	Goulac-water	Bordeaux mixture	Average
	gms.	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*	*gms.*
Acid lead arsenate	11	2,638	3,290	1,979	73	130	217	140
Basic lead arsenate	8,546	9,969	11,166	9,893	308	330	324	320
Calcium arsenate	3,472	7,087	12,059	7,839	160	192	300	217
Zinc arsenite	4,304	3,211	7,484	4,999	226	188	320	244
Magnesium arsenate	12,456	8,961	18,915	13,444	404	325	509	412
None	6,546	8,784	11,206	8,845	296	376	310	327
Untreated checks	12,386	8,179	12,616	11,060	400	332	397	376

The formulae used for the various spray and dust mixtures were as follows:

Arsenical 3 lbs., Kayso or Goulac 3 lbs., water 100 gallons
Arsenical 3 lbs., Bordeaux mixture (4. 6. 50) 100 gallons
Arsenical 1 lb., hydrated lime 4 lbs.
Arsenical 1 lb., Monohydrated copper sulfate 15% / Hydrated lime 85% } 4 lbs.

The bean beetle was prevalent throughout the summer, and injury to the foliage of untreated rows was conspicuous but in no case was it very evident that the yield of beans or growth of plants was thereby affected. Two pickings were made on August 25 and October 19 respectively. The plants were weighed individually from October 19 to 23, a period of comparative inactivity.

The results are given in Tables 1 and 2.

TABLE 2. THE COMPARATIVE WEIGHTS OF PODS AND VINES OF BEANS DUSTED SIX TIMES WITH ARSENICAL MIXTURES

Arsenical ingredient	Weight of pods per row, Dust mixture				Average weight per plant, Dust mixture			
	Hydrated lime		Copper-lime	Average	Hydrated lime		Copper-lime	Average
	plants moist	plants dry			plants moist	plants dry		
	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.
Acid lead arsenate	1,703	1,942	4,489	2,711	56	100	205	120
Basic lead arsenate	5,107	6,785	10,907	7,599	189	167	270	208
Calcium arsenate	1,520	3,803	9,601	4,974	82	54	241	125
Zinc arsenite	7,903	5,056	10,287	7,748	272	134	312	239
Magnesium arsenate	9,254	8,281	10,010	9,181	241	174	292	235
None	7,456	4,167	13,531	8,384	179	114	272	188
Untreated checks	9,494	6,862	9,443	8,599	312	187	253	250

The most noteworthy features of the above data are the consistently good showing of magnesium arsenate and basic lead arsenate, and the invariable effect of bordeaux mixture in enhancing the value of all arsenical mixtures. This is particularly true in the case of calcium arsenate, where the standard attained permitted of a satisfactory comparison with the more reliable but more costly arsenical mixtures.

In the case of dust mixtures magnesium arsenate was again the most consistently satisfactory arsenical tested. Zinc arsenite and basic lead arsenate averaged slightly lower results owing evidently to their inferior showing with hydrated lime dusts. On the other hand copper-lime dust served in a conspicuous manner to improve the results with all arsenicals. In the cases of basic lead arsenate, zinc arsenite, and calcium arsenate, the level attained was quite satisfactory. With hydrated lime mixtures, dusting the plants when dry invariably resulted in a relatively higher yield than when the plants were dusted moist with dew.

TESTS ON STRING BEANS. The purpose of the experiment with string beans was to ascertain what effect, if any, spray mixtures containing various proportions of hydrated lime had in lessening the extent of plant injury caused by the use of calcium arsenate.

Beans were planted on July 18 and August 8 in rows thirty-three feet in length. Each planting consisted of eight rows, three of which were sprayed by hand with mixtures of hydrated lime and water, and three others with bordeaux mixture of differing lime content. In addition, calcium arsenate was included in each of the above spray mixtures and was applied to only one-half of each treated row.

The spray formulae were as follows:

Calcium arsenate 3 lbs Hydrated lime 3, 6, or 9 lbs. Water 100 gallons	Calcium arsenate 3 lbs. Bordeaux mixture 100 gallons (4.6.50) (4.9.50) (4.12.50)

The mixtures were applied 4 times in the case of the earlier planted series, namely on August 12, August 18, August 28, and September 10, and in the case of the later planted series 3 times on the three later dates respectively. The rate of application averaged 200 gallons per acre.

Injury by the Mexican bean beetle was generally prevalent, and evidently in this case caused a slight decrease in yield in those sections not sprayed with calcium arsenate. The results should be interpreted with this in mind and should not be considered unreservedly as due to the effect of hydrated lime in lessening arsenical injury.

The results are given in Table 3.

TABLE 3. COMPARATIVE YIELD OF BEANS FROM PLOTS SPRAYED WITH MIXTURES CONTAINING VARIOUS PROPORTIONS OF HYDRATED LIME

Spray mixture	Test 1 (calcium arsenate added to spray) gms.	2 gms.	Average gms.	Test 1 (no arsenical added to spray) gms.	2 gms.	Average gms.
Hydrated lime 3–100	3,579	4,579	4,079	2,676	2,605	2,640
6–100	3,957	4,710	4.334	2,902	2,818	2,860
9–100	4,276	4,910	4,593	3,983	2,931	3,457
Bordeaux mixture 4.6.50	5,513	5,321	5,417	3,807	3,221	3.514
4.9.50	3,940	4,447	4,194	2,825	2,718	2,771
4.12.50	3,594	4,076	3,835	2,802	2,031	2,416
Untreated checks	3,210	3,752	3,481	2,955	2,155	2,555

The most significant feature of the results given above is in the fact that the yields were increased in the case of hydrated lime sprays according to the increase in the lime content, whilst in the case of bordeaux mixture the yields were gradually decreased according to the increase in the lime content of the spray. The highest yields were ob-

tained in the rows sprayed with bordeaux mixture prepared according to the standard formula, 4.6.50.

Undoubtedly there is a tendency for more copper to remain on the leaves and flowers when applied by means of a spray mixture containing increased quantities of hydrated lime, with the evident result that the decrease in yield from plants sprayed with such mixtures may be due to an increased amount of copper residue on the plant. On the other hand the above data indicate that in the case of calcium arsenate and hydrated lime an increase of spray residue on the plant from such a cause did not have a harmful effect.

Summary

Magnesium arsenate was the safest arsenical added to spray and dust mixtures for the control of the Mexican bean beetle, at the same time it was one of the most expensive. Basic lead arsenate came next from the point of view of safety to plant growth, but the material is no longer readily available for the eastern grower.

Zinc arsenite and calcium arsenate gave inferior results except when used with copper-lime treatments. Bordeaux mixture and copper-lime dust served to lessen in a high degree the harmful effects of arsenical compounds, and in the case of calcium arsenate, the most generally used and cheapest of all arsenicals for truck crops, made it possible to use this material with some assurance of success.

OBSERVATIONS ON THE POTATO TUBER MOTH

By George S. Langford and Ernest N. Cory, *University of Maryland, College Park, Md.*

Abstract

On three occasions during the past nine years the potato tuber moth (*Phthorimaea operculella*) has caused economic losses to potato growers in Worcester and Somerset Counties. During two years, 1925 and 1930, the damage was serious. In 1929 it was slight. Temperature is an important factor regulating the rate of growth in all stages of the insect. Outbreaks coincide remarkably with certain climatic factors. Hot and dry years seem to be most favorable for development. Every year in which the insect has been abundant the temperatures during the growing season were far in excess of the normal, and the rainfall below the normal. This combination of factors was outstanding for the months April to July. Calculations based on the number of day degrees required for development indicate that years in which the tuber moth occurred there was a sufficient accumulation of day degrees to make possible an additional brood of the insect. The intensity of the infestations in a given area appears to vary in proportion to the amount of rainfall.

The potato tuber moth, a serious pest of potatoes, is not normally a factor in potato production in Maryland, yet on three occasions during the past nine years this insect has caused economic losses in two of the lower Eastern Shore counties; Worcester and Somerset. During two years, 1925 and 1930, it was serious. Slight damage was incurred in a number of fields during 1929. In 1925 and 1930 the potato tuber moth was found damaging an occasional potato field in all Eastern Shore counties with the exception of Cecil, Kent and Queen Anne's. In the extremely hot and dry year of 1930, it was recorded from Bowie, Prince George's County and Frederick, Frederick County on the Western Shore.

These outbreaks of potato tuber moth coincide remarkably with certain general climatic factors. A preliminary study of the life habits of the insect indicate that temperature and moisture, especially rainfall, control to a large extent its development and abundance.

LIFE HISTORY STAGES AND TEMPERATURE RELATIONS.[1] Temperature is an important factor in the development of all stages of the potato tuber moth. It influences both the time required for development, and the number of broods that are likely to occur in any particular period. Since the potato tuber moth does not appear to have any true hibernation period, temperature may be the limiting factor in survival.

The Egg: When temperatures are maintained above 52°, and below 96°, the incubation period will vary from 3 days to more than 15 days, depending upon the mean average temperature. Table 1 gives the incubation periods recorded at various temperatures. If eggs are held at low temperatures that frequently fall below 52° the time required for hatching is much longer. Eggs have been kept for 52 days before hatching and subjected to temperatures from as high as 95° to below freezing without apparent damage to their vitality. At high temperatures the hatching of all eggs from any particular batch usually occurs within from 2 to 4 hours, while at lower temperatures all the eggs usually hatch within 24 hours.

Humidity appears to have a slight effect on the incubation period. At a mean average temperature of 93.2° it required on an average of 2½ hours longer for eggs at 3% humidity to hatch than eggs at 100% humidity.

The larva: Normal activities appear to occur between temperatures of from 52° to 103°. Larvae have been observed to crawl at 45°. They crawl rather freely at 52°. Apparently larvae are capable of living long periods

[1]All temperatures expressed in degrees Fahrenheit. All data taken from records at Public Landing unless otherwise indicated.

at low temperatures, and withstanding severe temperature changes. Individuals during experimentation have survived a 13-day period in potatoes packed in snow. On one occasion 25 larvae were transferred from a temperature of 80° to a temperature below freezing, and allowed to remain for a period of 20 hours. During this period the temperature dropped to 17°—nine of the larvae survived.

Newly hatched larvae can also withstand considerable temperature shock. They can withstand sudden transfers from temperatures as high as 95° to freezing without apparent injury. Larvae hatched at 95° have been removed to temperature conditions varying from 22° to 54°, and held for ten days without food. At the end of this period these larvae were transferred to a temperature of 80° where they entered potatoes and completed their development.

At temperatures above 52° and below 92° the period of development varies from an average of 9 days at 89.9° to an average of 33 days at 62.8°. Table 1 gives the data for several temperatures. Should the temperature fall below the threshold of development and remain below for long periods, the larval period may last several months.

The period required for development is very irregular, even when food conditions and temperature are kept apparently the same. At a mean average temperature of 80.1° the average period for development was 12 days, the minimum 10 days and the maximum 19 days. Normally the larvae develop under conditions in which the humidity is high. However, any conditions which permit contact moisture are extremely detrimental to the larvae.

The Pupa: At temperatures above 52° the pupal period may last on an average of 6 days at a mean average temperature of 90.1° or 26 days at a mean average temperature of 62.6°. See Table 1 for additional data. If temperatures are permitted to fall below 50° the period of development may last for several months. The transfer of 10 pupae from 80° to 17° over a period of 20 hours did not produce a single death.

The period of development is irregular under identical temperature conditions. At a mean average temperature of 78° the average pupal period was 10 days, the minimum 8 days and the maximum 11 days. Pupae have been developed in all humidities varying from 3% to 100%.

The Adult: The moths are fairly active between 58° and 60°. At 52° they crawl, but do not fly. Exposure for several hours to temperatures as low as 17° is neither fatal nor does it affect the ability of the moths to lay eggs. Eggs from individuals receiving such exposure hatch normally. Moths are capable of laying viable eggs in humidities varying

from 3% to 100%. The writers have observed mating at all temperatures from 64° to 95°. Graf[2] reports moths mating at temperatures from 59° to 65°. Oviposition has been observed taking place at temperatures as low as 55°. Moths moved from a warm laboratory have been recorded as laying at temperatures as low as 44°. At temperatures of around 85° newly emerged moths have been observed to mate and lay viable eggs within a period of 36 hours.

TABLE 1. EFFECT OF TEMPERATURE ON THE DEVELOPMENT OF THE POTATO TUBER MOTH

Average Hourly Temp.	Average time required for development			Average effective day degrees above 52° F.		
	Eggs	Larvae	Pupa*	Eggs	Larvae	Pupa*
60–61	15 da.			123.1		
63–64		33 da.	26 da.		356.4	
71–72	6 da. 8 hrs.			122.2		
73–74	5 da. 20 hrs.			122.9		
74–75			12 da.			274.0
75–76	5 da. 8 hrs.		10 da.	126.9		237.5
76–77	5 da. 4 hrs.		11 da.	125.5		264.0
77–78	4 da. 20 hrs.		10 da.	125.2		252.5
78–79		13 da.	10 da.		338.0	260.0
80–81	4 da. 8 hrs.	12 da.		121.7	337.2	
87–88		10 da.			356.0	
89–90	3 da. 8 hrs.	9 da.		123.3	338.4	
90–91			6 da.			
93–94	3 da.					
94–95	3 da.		7 da.			
95–96	3 da.					
102–103	4 da. 4 hrs.					
Unweighted averages				123.8	345.2	257.6

*The pupal period in this work is considered as the time from which the full grown larva began to spin a cocoon until the adult emerged.

The above data is typical, but represents only a small portion of that available. The number of individuals used in each experiment varied. The total number used in the above experiments are: Eggs 783, larvae 206, pupa 290.

EFFECT OF TEMPERATURE SUMMATIONS. Effective day Degrees: By plotting the reciprocal value of the time factor against the temperature factor the theoretical threshold of development for the several stages was determined as being near 52°. Therefore, this threshold has been used in all the studies included in the paper. The temperature at which development is retarded has not been accurately determined and therefore has been given no consideration. Retardation apparently occurs at some point between the temperatures of 90° and 95°. For the field studies, thermograph records were not available, therefore the effective day degrees were computed from maximum and minimum temperatures

[2]U. S. D. A. Bulletin 427.

[3]Bulletin Illinois Natural History Survey, Vol. 14, article VII.

by the use of formulae stated by Glenn[8] to give the approximate effective day degrees. It is realized that the above methods do not give accurate information, but it is believed to be sufficiently accurate to permit valuable generalizations.

Excluding the humidity factor, the number of effective day degrees required for the several stages are given in Tables 1 and 2.

TABLE 2. EFFECT OF TEMPERATURE ON THE DEVELOPMENT OF THE POTATO TUBER MOTH (Newly Hatched Larvae to Adults)

Mean average hourly temp.	Average time required for development Days	Reciprocals of periods	Effective day degrees above 52° F. Max.	Min.	Aver.	Number of individuals
63.4	49	.020	620.1	526.4	558.6	25
78.6	22	.045	748.8	423.0	585.2	70
78.8	22	.045	973.6	412.0	589.6	92
88.3	16	.060	920.0	505.8	580.8	35
90.6	16	—	—	—	—	50
		—	—	—	—	—
Unweighted average			815.6	466.8	578.5	272
		Eggs to Adults				
61.3	57	.017	752.1	532.5	682.3	25
78.2	26	.038	998.1	501.5	680.1	102
78.2	27	.036	874.8	544.0	706.2	57
88.9	19	.050	—	615.0	704.1	19
90.8	18	.055	817.2	646.0	699.5	11
			—	—	—	—
Unweighted average			860.5	567.8	694.4	214

Experiments starting with the egg deposited naturally on potatoes and undisturbed afterwards have shown that it requires an average of 694.4 effective day degrees for development from egg to adult. The minimum period required in any experiment was 501.5 effective day degrees and the maximum was 998.1 (Table 2). In experiments starting with newly hatched larvae on potatoes and undisturbed thereafter, one finds by summing the averages, that the average period is 703 effective day degrees, the minimum 585.4 and the maximum 946.7. By summing the average effective day degrees for individual stages, the total effective day degrees for development is somewhat higher. The average is 726.6, the minimum 598.1 and the maximum 1022.9 effective day degrees. For the purpose of these studies 700 effective day degrees are considered as the average.

Table 5 gives the number of effective day degrees calculated for field conditions.

CLIMATIC FACTORS. An examination of climatic conditions from the years 1924 through 1930 present some very striking climatic variations.

The coincidence of potato tuber moth with hot and dry years is marked. The area, Worcester and Somerset Counties where the insect occurred in injurious numbers is characterized by a climate that makes it the warmest and one of the dryest areas in the state with the exception of the southern tip of southern Maryland on the western shore. This area has one of the longest growing seasons, 210 days, in the state. The average annual temperature is between 57° and 58°, and the average annual rainfall is between 38 and 40 inches.

TABLE 3. TEMPERATURE AND RAINFALL DATA PUBLIC LANDING, MARYLAND

	Mean temperature Degrees F.				Rainfall Total inches				
Year	April May June	July Aug. Sept.	April to Oct.	Mean for Year	April May June	July Aug. Sept.	April to Oct.	Total for Year	Tuber moth
1924	59.7	70.8	65.3	54.0	17.70	10.35	28.08	44.27	
1925	63.3	73.3	68.3	56.2	3.42	6.10	9.52	33.09	Severe
1926	59.2	74.0	66.6	54.3	7.31	19.41	26.72	48.29	
1927	59.2	70.7	65.0	55.4	9.63	12.31	21.94	46.42	
1928	60.2	73.0	66.6	55.3	10.20	13.10	23.30	34.92	
1929	63.7	72.5	68.1	56.5	11.63	8.85	20.48	41.51	Slight
1930*	65.2	76.9	71.0	58.2	7.46	2.66	9.07	23.98	Severe

*Temperature and rainfall data from Chrisfield, data from Public Landing not available.

Temperature: An examination of the average of the monthly temperatures from weather bureau records for the months in which potatoes are growing, April to October (Table 3) shows that the years 1925, 1929 and 1930 were the warmest for the period under consideration. If compared with the next warmest year, 1928, there will be noted that tuber moth years had excess temperatures as follows: 1925 (+1.7°); 1929 (+1.5°); 1930 (+4.4°). When one considers this average excess is operating over a period of 183 days it would appear to be significant. Probably more significant is the fact that during the spring period, April, May and June, when the insect is getting its start, the excess temperatures were still higher. Compared on the same basis as above, the following excesses occurred: 1925 (+3.1°); 1929 (+3.5°); 1930 (+5.1°). Moreover, in tuber moth years the entire year was warmer than any other under consideration. This same condition prevailed for the month of March, or planting time.

The difference in temperature for the years under consideration may be better visualized by the use of daily temperature summations for the year, above or below the normal as recorded by the weather bureau.

There are no major weather stations in the immediate vicinity of the localities in question, but it is felt that the station at Norfolk, Virginia, will give an indication for the general area.

Examination of Table 4 shows that tuber moth years had higher temperatures. The difference between the hottest year 1930 and the coldest year 1924 is 748°. Considering the period from January 1 to October 1, the period in which the insect must build its population, the difference is more outstanding. Every year in which the potato tuber moth was not injurious there was a deficiency varying from 50° to 291° except 1928 which showed an excess of 3°. In each of these years the spring months were cold. For the years in which potato tuber moth injury was severe in Maryland: namely, 1925 and 1930, the excess on October 1 was 513° and 581° respectively. In 1929 when damage was general but slight, the excess was 258°.

TABLE 4. SUMMATION OF DAILY TEMPERATURES ABOVE OR BELOW THE NORMAL, FROM JANUARY 1 TO DATE INDICATED, AS RECORDED BY THE WEATHER BUREAU AT NORFOLK, VIRGINIA, 1924 TO 1930

Norfolk, Virginia

Period from Jan. 1 to —	1924	1925	1926	1927	1928	1929	1930
April 1	—62	+289	— 56	+258	+52	+201	— 39
July 1	—149	+409	—181	+ 78	—13	+325	+367
October 1	—291	+513	— 54	— 50	+ 3	+258	+581
December 31	—263	+290	— 93	+191	+91	+262	+485
Tuber moth injury		Severe				Slight	Severe

Plus (+) above normal—Minus (—) below normal.

Applying the principal of effective day degrees, an examination of Table 5 shows large temperature differences. In those years in which the tuber moth occurred, the number of effective day degrees for the period April 1 to October 1, ran in excess of 3,000. The spring months, April to July of 1925, 1929 and 1930 afford a more favorable temperature for early development than any of the other years. The difference for this period between 1924 and 1925, for example, was 311.9 effective day degrees. Considering the six months period from April to October the difference is less marked. However, comparing the coldest year 1927 with the warmest year 1925 there is a difference of 551.4 effective day degrees. From the standpoint of temperature alone, 1928 was probably the most favorable of the non tuber moth years for tuber moth development. According to the total effective day degrees indications are that 1926 should have been a favorable year, but besides having a cold spring and an excessive rainfall for the growing period, the retardation effect of the eleven days with temperatures in excess of 90° in August probably tended to reduce the value of the large accumulation of effective day degrees.

If effective day degrees are used as a basis for calculating the possible number of broods that could have occurred for the six months period,

April to October, for the different years some interesting results are noted. Comparing the years of 1924 and 1925 and using the minimum number of day degrees (501.5) required for development, 1924 had, theoretically, 5.16 broods, while 1925 had 6.25. If the average of 700 effective day degrees is used, 1924 had 3.72 broods against 4.48 broods for 1925.

TABLE 5. CALCULATED EFFECTIVE DAY DEGREES FOR FIELD CONDITIONS—PUBLIC LANDING, MD.

	1924	1925	1926	1927	1928	1929	1930*
April	71.9	157.0	84.9	80.7	102.9	186.5	93.2
May	263.5	276.2	289.5	334.5	271.5	365.2	393.0
June	524.7	738.8	483.4	436.1	543.8	601.6	588.0
Total	860.1	1172.0	857.8	851.3	918.2	1153.3	984.2
July	664.0	778.5	746.4	678.0	746.5	734.6	749.3
August	690.0	596.9	764.6	555.2	775.1	628.1	646.0
September	392.8	592.9	517.8	504.4	432.8	528.9	624.8
Total	1746.8	1968.3	2028.8	1737.6	1955.2	1891.6	2020.1
Total for six months period	2606.9	3140.3	2886.6	2588.9	2873.4	3044.9	3004.3
Tuber moth injury		Severe				Slight	Severe

*Princess Anne—Records for Public Landing are not available.

No accurate information is available on the number of broods occurring in Maryland in any of the years, but Poos and Peters[4] made some very careful observations on the number of broods occurring at Onley, Virginia during 1926 and 1927. In 1926 five complete generations and a partial sixth generation occurred, while in 1927 there were four complete generations and a partial fifth generation. An examination of the temperatures at Onley for the six months period, April to October, shows an average of 69.7° for 1926 against 67.4° for 1927 or a difference of 2.3° operating over a period of 183 days. Applying the effective day degree calculations for these two years at Public Landing for the period, April to October, theoretically 4.1 generations for 1926 and 3.6 generations for 1927 could have occurred.

All indications point to the supposition that in years when tuber moth has been injurious the temperature was sufficient to produce an extra brood. In the case of an insect with as high a rate of development as the tuber moth, this may have considerable influence on the amount of damage. Moths normally deposit from 150 to 250 eggs. Graf[5] taking 150 eggs as the average, estimated that one pair could theoretically produce 60 million adults at the end of the fourth generation.

[4]Va. Truck Exp. Sta. Bul. 61.

In calculating the number of effective day degrees required for development from egg to adult, tubers were used to rear the insect. Graf[3] states that "larvae developing in leaves, stems or petioles grew more rapidly than those in the tubers." If this is true a greater number of generations would be possible than indicated above.

Rainfall: Many investigators have observed that outbreaks of the potato tuber moth are incident to dry years. The amount of rainfall and the time it occurs appears to have a decided effect upon tuber moth abundance.

Table 3 shows that years in which the potato tuber moth occurred in injurious numbers were dry, but more marked is the fact that the spring and summer months were dry. A close study of the data clearly indicates that a dry year is not necessarily a tuber moth year, or is a wet year a non tuber moth year. If this was the case 1928 with only 34.9 inches of rainfall should have been a tuber moth year, while 1929 with 41.5 inches should have been a non-tuber moth year. The actual conditions were exactly opposite. In 1928 the spring and summer months, April to October, were exceedingly wet, 23.3 inches of rain. In 1929 the spring was wet, but the summer months, July to October, were comparatively dry. From the standpoint of temperature 1926 might have been a tuber moth year, but the rainfall was excessive, 26.7 inches fell from April to October. The two years, 1925 and 1930, in which the insect was most serious, had some rather remarkable features which appeared to influence tuber moth abundance. The total rainfall for the two years was 33.09 and 23.98 inches respectively. At the end of the six months, April to October, the total amount of rainfall was 9.52 inches in 1925 and 9.07 inches in 1930. While exact quantitative data relative to the degree of infestation for the two years are not available, the year of 1925 was the only one in which tuber moth was observed to injure to any extent the first crop of potatoes. This was apparently influenced by rainfall. The spring months, April to July, 1925, only 3.42 inches of rain fell as against 7.46 inches for 1930.

A more intimate picture of the apparent influence of rainfall may be obtained by an examination of rainfall data for several localities in which the moth occurred in 1929 and 1930. In 1929 the intensity of the infestation in tubers at the time of harvest varied as follows: Public Landing area 2 to 5% tuber infestation; Pocomoke City area 0 to 4% tuber infestation; Crisfield (Marion) area 5 to 8% tuber infestation. The rainfall for these areas for the period, May to October was: Public Landing 15.93 inches, Pocomoke 13.29 inches and Crisfield 11.56 inches.

The 1930 rainfall data for Public Landing are not available, but for the period, April to October, the rainfall at Pocomoke was 11.98 inches against 9.07 for Crisfield. The degree of tuber infestation varied from 7% to 15% for the Pocomoke area against 16% to 34% for the Crisfield (Marion) area.

The fall months, October to January, in the years preceding outbreaks have always been comparatively dry. The maximum rainfall in the fall preceding any outbreak was 6.55 inches in 1929 and the minimum of 4.78 inches in 1928.

SPRAYING AND DUSTING EXPERIMENTS FOR THE CONTROL OF POTATO APHIDS

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ABSTRACT

Data regarding the distribution of aphids on plants before and after treatment are provided. The effect of mechanical factors such as machinery and pressure are discussed. Preliminary data regarding the effect of Bordeaux on the prevalence of entomophagus fungi are presented. The relative toxicities of the various substances used in the field tests are indicated.

A series of experiments to determine the relative toxicities of materials and the mechanical efficiency of spraying and dusting procedures against potato aphids have been conducted on Long Island during the two seasons just past. While aphids have apparently caused no reduction in yield in this region during 1930 and 1931, some interesting data have been obtained.

During the season of 1930 the following method of counting was used, and it is upon actual counts of aphids that this report is based. Five stations were selected at random in the outside row of the first plot of six rows. A single plant was selected at each station; three leaves of this were chosen and the number of insects on each leaf counted. One leaf was taken at the base, another at the middle and a third at the top of the plant including the blossom. Each leaf was marked with a white paper tag before the count was made. In this way it was possible, on the recount taken within twenty-four hours, to record the insects on the same leaves before and after treatment. Stations having been established in the first row, those in subsequent rows were chosen in lines parallel across all plots. In this way comparable data were obtained. Three rows

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of each six were used in making counts. One was an outside row which would be undisturbed by the passage of horses and machinery. Another was a row next to the outside and the last was a true inside row over which machinery would pass.

In 1931 the same method was followed except that only two rows were counted in each plot of six—an outside and an inside row. This was felt to be feasible in as much as the figures from 1930 (Table 1) indicated that there was no material variation in the effect of mechanical equipment on the infestation of aphids on the four inside rows of each plot.

TABLE 1. COMPARATIVE DISTRIBUTION AND AVERAGE NUMBERS OF APHIDS ON POTATO PLANTS AND ON PLANTS IN DIFFERENT ROWS OF A SIX ROW PLOT

Row	Tops	Middles	Bottoms	Totals	Averages
True outside	4,296	2,684	3,974	10,954	3651.3
Inside	4,254	1,746	3,652	9,652	3217.3
Second from outside	4,323	2,499	4,161	10,983	3661.
Totals	12,837	6,929	11,787	31,589	
Averages	4,291	2309.7	3,929		

These data were shown to be significant statistically.

There has been some discussion in the literature as to the effect of the pressure utilized in spraying materials. Some workers have considered that the force with which the spray was applied had no inconsiderable affect on the efficiency of the material as expressed in the kill obtained. In order to test this matter under field conditions it was decided to apply water alone at a pressure of 400 lbs. per sq. in. The results are shown in Table 2. In one replication a slight reduction in the infestation is recorded. In another replication it will be seen that even in spite of the water the infestation had increased in the twenty-four hour period. Apparently, the only effect of pressure is to be looked for in the better distribution of toxic substances.

In 1930 a comparison of the relative numbers of aphids on plots sprayed, dusted or untreated from the beginning of the season was made. This showed that there were actually more aphids on the treated than on the untreated vines. While there were more aphids on the dusted plots than on the checks, and more on the sprayed than on the dusted, it was found by treating the figures statistically that the only significant difference was that between the sprayed and the untreated plots. Similar differences in infestation were also found in Upstate New York. It is suggested that the reasons for these differences may be found in a phototropic response on the part of the aphids.

The manner in which counts were taken enables one to study the relative distribution of aphids on various parts of the plant. Of some 32,000

aphids counted in 1930, slightly more than forty per cent were found near the tops of the plants, 20½ per cent were near the middles of plants and the rest, or 38½ per cent, were located on leaves which were touching the ground. The large percentage of aphid population found on

TABLE 2. EFFECTIVENESS OF MATERIALS AND THE MECHANICAL EFFECTS OF TREATMENTS IN REDUCING NUMBERS OF APHIDS*

Treatment	Total number of aphids Before treatment	After treatment	Decrease in numbers of aphids due to treatment	Percentage decrease in numbers of aphids due to treatment
Penetrol (1) Nicotine	2,304	1,116	1,188	51.56
Penetrol (1) Nicotine	2,188	1,203	985	45.01
Bordeaux (2) Penetrol Nicotine	2,750	1,740	1,010	36.72
Bordeaux (2) Penetrol Nicotine	1,585	1,140	445	28.07
Water (3)	2,303	2,129	174	7.55
CHECK	2,849	2,487	362	1.27
Water (3)	3,519	3,623	—104	—2.87
CHECK.....	2,499	2,661	—162	—6.48
CHECK.....	2,142	3,458	—1,316	—38.05

*A heavy rain followed immediately after treatment so that the effectiveness of the various sprays was greatly reduced. It may be assumed that the relative efficiency of these sprays under these conditions remains the same.

These data were treated statistically and all differences were found to be significant.

(1). 200 gal. water; 1 gal. Penetrol; ½ pt. Black-leaf 40.

(2). 200 gal. Bordeaux (4–4–50); 1 gal. Penetrol; ½ pt. Black-leaf 40.

(3). 200 gal. water.

Pressure thruout 400 lbs. per sq. in.
Humidity 50% Temperature 82°.

the lower portions of the plants indicates very clearly the necessity of making very thorough applications of any materials designed for aphid control. This is perhaps brought out more forcibly by the figures obtained on the recount after the application of materials. It was found that of the aphids surviving treatment, 32 per cent were on top leaves, 17½ per cent were near the middles of plants, and 50½ per cent were found near the bottoms of plants. The distribution in 1931 was 24.2 per cent near the tops, 24 per cent near the middles, and 51.8 per cent near the bottoms of plants. It is quite evident, then, that the methods used in both dusting and spraying were not of the highest order of efficiency. Apparently, too much stress cannot be laid on the adjustment of booms and the use of sufficient pressure to insure the greatest possible distribution of materials.

An attempt was made to determine, in a preliminary manner, what effect spraying with bordeaux might have upon the prevalance of the entomophagus fungi which seem to keep the aphids so well in check. Counts were made of diseased and healthy aphids on plots which had

TABLE 3. EFFECTIVENESS OF MATERIALS IN REDUCING NUMBERS OF APHIDS—1930

Treatment	Total numbers of aphids Before treatment	After treatment	Decrease in numbers of aphids due to treatment	Percentage decrease in numbers of aphids due to treatment
3 per cent (1) dust on spray	1,763	44	1,719	97.50
3 per cent (1) dust on dust	3,117	92	3,025	97.04
spray (2) on spray	1,311	89	1,222	93.21
spray (2) on spray	3,701	253	3,448	93.16
spray (2) on dust	1,817	130	1,740	93.04
spray (2) on dust	3,408	660	2,748	80.63
spray (2) on dust	2,867	636	2,232	77.82
2 per cent (3) dust on spray	3,630	1,013	2,617	72.09
2 per cent (3) dust on dust	2,661	1,144	1,517	57.00
CHECK*	2,012	959	1,053	52.33
CHECK	2,192	2,104	88	.40

*Wind drift from 3 per cent dust plot.
(1) 1½ qts. Black-leaf 40 to 50 lbs. hydrated lime.
(2) 1 pt. Black-leaf 40, 6 lbs. hard potash fish oil soap; 100 gal. water.
(3) 1 qt. Black-leaf 40 to 50 lbs. hydrated lime.

received different treatments. While the figures are scarcely large enough to warrant definite statements, they indicate a need of further investigation. On a check plot untreated throughout the season 14.3 per cent of the aphids counted were diseased. On a plot previously sprayed with bordeaux 8.79 per cent of those counted had been attacked by the fungus and on a bordeaux-lead arsenate plot but 4.6 per cent were found infested. The number of aphids involved was about 7,000. It was consistently noted that most of the aphids attacked belonged to the species *Macrosiphum solanifolii*. Only occasionally was a representative of *Myzus persicae* found infested. Observations in Maine during the past summer substantiate this observation from Long Island. It was also noted fre-

quently that of aphids surviving treatment a large proportion were the young of *M. persicae*. This condition seemed especially true near the soil line. In general it was found that dusting with a canvas trailer was more effective than spraying in the control of this pest. Materials

TABLE 4. EFFECTIVENESS OF MATERIALS IN REDUCING NUMBERS OF APHIDS, 1931

Treatment	Total numbers of aphids Before treatment	After treatment	Decrease in numbers of aphids due to treatment	Percentage decrease in numbers of aphids due to treatment
3 per cent (1) nicotine dust	20,878	920	19,958	95.59
2 per cent (2) nicotine dust	19,983	1,167	18,816	94.16
3 per cent (1) nicotine dust	13,023	2,006	11,017	84.59
Soap nicotine (3)	10,562	2,890	7,672	72.64
soap nicotine (3)	12,548	4,574	7,974	63.54
Bordeaux (4) nicotine	10,198	4,331	5,876	57.53
CHECK dust vs. spray	13,799	4,107	9,892	70.66*
CHECK—dust	21,942	11,991	9,951	45.35*
CHECK soap-Bordeaux	10,990	11,845	—855	—7.78

*Wind drift from dust plots.
(1) 3¾ lbs. Black-leaf 40 to 50 lbs. hydrated lime.
(2) 2½ lbs. Black-leaf 40 to 50 lbs. hydrated lime.
(3) Black-leaf 40 1 pt.; liquid potash fish oil soap 6 lbs.; water 100 gal.
(4) Bordeaux (5–5–50) 100 gal.; Black-leaf 40 1 pt.

were found to be more effective when applied to plots which had been sprayed throughout the season with Bordeaux than to those which had been treated with an 80–20 dust. Sprays containing potash fish oil soap were uniformly more efficient than any other liquid material. Penetrol and nicotine gave better results than did those two liquids when added to Bordeaux mixture.

In the 1931 experiment in one case the amount of nicotine was reduced by one-half. As might have been expected, the result was rather disastrous from the standpoint of control. It would appear from this result that it is not advisable to reduce the nicotine content of a spray below the generally accepted strengths.

SUMMARY

Mechanical factors influence the efficiency of materials toxic to aphids to a relatively slight degree. The greatest effect seems to be exerted in the manner of distribution of materials. That this is important is shown by a study of the distribution of aphids before and after treatment. A limiting factor in the increase of aphids is found in certain fungus diseases. These diseases appear to be influenced by present spray practices. Dusting for aphids, if weather conditions be favorable, is shown to be as efficient a method as any tested.

BIOLOGY OF THE POTATO LEAFHOPPER, *EMPOASCA FABAE* (HARRIS)[1], AND SOME CLOSELY RELATED SPECIES OF *EMPOASCA*

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ABSTRACT

A preliminary summary of studies on the comparative biology of the potato leafhopper, *Empoasca fabae* (Harris), and five closely related species of *Empoasca* (all described by DeLong) as follows: *abrupta, bifurcata, erigeron, recurvata, solana.* Evidence is presented which indicates that *E. fabae* does not overwinter in the north but migrates northward each season.

The observations upon which this paper is based were made at Arlington Experiment Farm (P. O. Rosslyn, Virginia) during 1929, 1930, and 1931. DeLong[3] in his recent revision of the genus *Empoasca* describes several new species which have undoubtedly been confused for many years with *E. fabae.* This situation renders much of the literature on this species of doubtful value. The recent work on this genus has only reëmphasized how essential it is to know the correct identity of any species in order to ascertain its correct economic status and its capacity for causing injury to its host plants. Because of this confusion in the

[1]Order Homoptera, family Cicadellidae.

[2]This paper is a part of a cooperative study of leafhopper injury to legumes by the U. S. Department of Agriculture between the Division of Cereal and Forage Insects, Bureau of Entomology, Dr. W. H. Larrimer, in charge, and the Office of Forage Crops and Diseases, Bureau of Plant Industry, Dr. A. J. Pieters, in charge. The writer is indebted to various individuals connected with the project for varying periods of time for much conscientious assistance which will be acknowledged more fully when the details of the work are published. Dr. D. M. DeLong, Ohio State University, kindly assisted with identifying the species studied, even prior to the publication of his recent revision of the genus *Empoasca.*

[3]Tech. Bul. 231, U. S. Dept. Agr., Bur. Ent., Jan. 1931.

literature, a detailed study of the biology of *E. fabae* and several of its close relatives of the genus *Empoasca* was started in 1929. In carrying on this work much special technic had to be developed because the species are small and extremely active and because many of them can not be definitely differentiated by morphological characters except by resorting to structures in the male genital chamber. These characters are concealed and can not be revealed and examined without preparation of the chitinous structures involving the destruction of the softer parts of the male genital chamber by soaking gradually in a 10 per cent solution of potassium hydroxide. The studies now described have progressed to a point where it is considered timely to present a preliminary summary of the observations to date and a brief discussion of the significance of some of these data.

METHODS. The life history studies were carried on in an out-of-door insectary. Cages used were of the cylinder type, 10 inches in height and 3¼ inches in diameter, made of celluloid, 0.015 inch in thickness, which was attached to a wooden stake by means of thumbtacks. One end of the stake extended about 1½ inches beyond the celluloid cylinder and was sharpened so that it could readily be pushed into the soil and thus hold the cage firmly over the host plant in a 4-inch flowerpot. The open end, top of the cage, was covered with cheesecloth held in place by two or more rubber bands. Studies in the insectary were started in the spring with the first females which appeared in the field. These females were isolated and offspring (male adults) were reared for identification before the identity of each species could be definitely determined. The identity of the males of all life history pairs was verified even though the pairs of each new generation were progeny of identified parents. Since the eggs of *Empoasca* are deposited within the plants, records on incubation, number of eggs deposited, etc., can be reckoned only by obtaining the time of and number of nymphs hatching. This necessitated changing the host plants in the life history cages daily. The period of exposure of each host plant to its life history pair was recorded. These plants were then examined daily for the appearance of nymphs, during the period when hatching was probable, in order to record the incubation period, number of eggs, etc. Upon hatching, the young nymphs were transferred to other cages where their development to adults was observed and recorded. Cowpea was used as a host plant for *fabae* and *recurvata*. Aster and Solidago were used for *bifurcata* and *erigeron*, and potato for *abrupta* and *solana*. The host material was grown in a heavily shaded greenhouse, screened with 30-mesh copper wire cloth,

or under properly protected cages out-of-doors, in order to prevent oviposition by *Empoasca* prior to its use in the life history cages.

LIFE HISTORY STUDIES. The several species are treated in alphabetical order under this heading. No period of aestivation or diapause was observed for any of the species studied. The generations greatly overlapped in the case of all species. Host plant records given in this paper refer only to reared material, i.e., nymphs were reared through to the adult stage on the plant upon which they were collected, indicating that the eggs had been deposited in the host. Males in each lot were then identified by means of structural characters of the internal genitalia. The feeding habits of four of the species treated in this paper were discussed in a previous paper.[4] The average duration of various periods of development are not given, as they do not appear to be at all significant unless correlated with temperature.

Empoasca abrupta DeLong. Mr. R. A. Blanchard of the U. S. Entomological Laboratory at Sacramento, California, kindly sent the writer living material of this species which he collected on potato and alfalfa. Females were first isolated at Arlington Farm, July 11, 1931, in order to secure pure stock. This species was found breeding on Calendula and injuring it severely at Leavenworth, Kansas, during August, 1931. Nymphs of this species were also obtained upon dahlia from Leavenworth and from Beverley, Missouri. It bred upon alfalfa, *Aster* sp., bean, red clover, *Solidago* sp., and sweet potato in confinement but seemed to prefer potato. This species appears to be the most prolific, except probably *fabae*, among those studied. A record of 17 eggs deposited in one day and a total of 217 eggs laid by one female was obtained. The period from egg to adult ranged from 19 to 54 days, based on incomplete records on the offspring of 16 life history pairs covering three generations. The maximum incubation period was 36 days, the minimum 9. The maximum period of nymphal development was 37 days, the minimum 10. Two attempts to crossbreed this species with *fabae* were unsuccessful.

Empoasca bifurcata DeLong. During 1930–31, detailed life history records were obtained upon 45 pairs of this species representing the last three generations in 1930, and four generations in 1931. The preoviposition period ranged from 3 to 17 days, the oviposition period extended as long as 130 days. The longest record on adult life was 148 days for the female and 120 days for the male. The incubation period ranged from 9 to 22 days and the entire period of nymphal development ranged

[4]Jour. Agr. Research 43:267–285. Aug. 1, 1931.

from 8 to 57 days. This species has been reared on *Aster* sp., *Erigeron* spp., false loosestrife (*Steironema ciliatum* (L.) Raf. identified by Dr. S. F. Blake, Bureau of Plant Industry), lettuce (wild), *Solidago* spp., tansy, *Vernonia altissima*, and in its habits resembles *Empoasca erigeron* most, among congeneric species studied. All attempts to crossbreed this species with other species of *Empoasca* were unsuccessful as follows: 22 attempts with *erigeron*, 7 with *fabae*, 11 with *recurvata*. In all of this work the two possible combinations were both attempted. In this case males and females of *bifurcata* were placed with the opposite sex of each of the other species. Adults of *bifurcata* were found commonly, but not abundantly, feeding on a wide variety of host plants, such as alfalfa, endive, rhubarb, and tansy, at Arlington Farm. It was collected at Hollister, Missouri, and Rio, Kentucky, during 1930, but the host plant upon which it was breeding was not ascertained. During 1931 it was taken in trap light at Knoxville, Tennessee.[5]

Empoasca erigeron DeLong. Life history observations on this species are based on 93 pairs representing a maximum of five generations during a single season. During 1930 all eggs deposited after September 23 did not hatch in the insectary but represented the overwintering eggs of this species. Hatching continued until October 21 during 1929 and until October 26 during 1931. The incubation period ranged from 8 to 32 days and the preoviposition period ranged from 3 to 41 days. One female lived 124 days and one male lived 142 days. The longest oviposition period was 92 days and the longest postoviposition period was 51 days. The period of nymphal development ranged from 9 to 42 days. A total of 1,411 records during 1930 disclosed that the nymphal period of males was 0.5 day less than that of the females, 685 records of which averaged 14.2 days. The period of nymphal development of the males of *bifurcata* and *fabae* was, on the average,, 0.78 day and 0.55 day shorter, respectively, than for females, based on 359 records on *bifurcata* and 1,065 records on *fabae*. All attempts to crossbreed this species with other species of *Empoasca* were unsuccessful, as follows: 22 attempts with *bifurcata*, 17 with *fabae*, and 7 with *recurvata*. This species has been reared from the following host plants: alfalfa, artichoke, *Aster* sp., burdock, carrot (wild), chrysanthemum, dahlia, dock, *Erigeron* spp., false loosestrife (*Steironema ciliatum* (L.) Raf.), ironweed, milfoil, ragweed (giant), tansy. It has been collected in Kansas, Maryland, Ohio, and Tennessee. In

[5]All habitat records from Tennessee reported in this paper were obtained through the kindness of Mr. W. W. Stanley who sent *Empoasca* from his trap light during 1931.

northern Virginia it is apparently the most abundant species of *Empoasca* next to *fabae*.

Empoasca fabae (Harris) (California strain). The writer is indebted to Mr. R. A. Blanchard who sent living material in October, 1929, with the information that the species was injuring alfalfa severely on his laboratory plat. This was apparently the first authentic record of the occurrence of this species in California as well as of the occurrence of the yellowing and dwarfing of alfalfa by *Empoasca* there. Females of this strain were isolated and the feeding habits were compared with those of *fabae* from the eastern part of the United States without noting any constant differences.[6] Alfalfa plants injured by this species and sent by Mr. Blanchard and by Dr. J. L. Weimer of the U. S. Bureau of Plant Industry at Riverside, California, have shown a greater preponderance of purples than is commonly found in plants injured by *fabae* here. Other factors may have entered into the cause of this condition. It was difficult to maintain a pure stock of this strain. It bred on cowpea and potato, but seemed to prefer alfalfa, which is very difficult to grow satisfactorily in 4-inch flowerpots in the insectary. This strain of *fabae* developed only three generations in the insectary while our eastern strain passed through six generations during the same period. This was probably due more to a lack of general vitality of the small number of pairs on hand, or to a dislike for cowpeas which were furnished it most of the time as a host plant, than to any inherent difference in duration of the various periods of development. Only a comparatively few records on development of this strain were obtained but the duration of the various periods compares favorably with that of eastern *fabae* except for the longevity of the adults, especially in the females, which was considerably shorter. Of the eight attempts to crossbreed this strain with eastern *fabae*, only two were successful. In these the progeny were not abundant and did not appear to be as active as those of eastern *fabae* normally are.

Empoasca fabae (Harris) (Virginia strain). Life history records were obtained upon 128 pairs of this species. A maximum of six complete generations have been reared during a single season. Cowpea was most suitable for this work except after September, when the plants would not thrive in the shade. It was then necessary to transfer most of the plants to the greenhouse, after exposure to their respective life history pairs, in order to get acceptable records on the number of eggs deposited and the date they were deposited. These records on incubation for insectary conditions were thus lost. Enough material was left in the in-

[6]Jour. Agr. Research 43:274.

sectary however, to make possible the determination of the number of generations which would develop there. The incubation period ranged from 4 to 23 days and the period of nymphal development ranged from 8 to 37 days. One female deposited eggs over a period of 95 days. Preoviposition periods ranged from 3 to 22 days, and one postoviposition period of 79 days was recorded. Maximum longevity for the female was recorded as 123 days, and for the male, 111 days.

This species has been reared from the following host plants: alfalfa, apple, bean (South American, Kentucky, mung, and various varieties of garden bean), clovers (alsike, Ladino, strawberry, white, zigzag, and numerous varieties of red and sweet clovers), Chinese chestnut, cowpea, cherry (flowering Japanese), eggplant, elm, hemp, hollyhock, Laburnum, locust, lupine, mallow, peanut, pokeweed, potato, redbud, rhubarb, rose, *Sophora japonica,* soybean, sunflower (cultivated) sweet potato, and walnut (English). Previous work[7] indicated that potato was the preferred host plant among those tested. The wide range of host plants of this species together with the additional number of generations which it develops each season are extremely significant in explaining its tremendous abundance and therefore its importance economically in comparison with its close congeneric relatives.

Attempts to crossbreed this strain with other members of the genus *Empoasca* were made as follows: 2 attempts with *abrupta,* 7 with *bifurcata,* 17 with *erigeron,* 10 with *recurvata,* and 8 with *fabae* (California strain). All results were negative except with the California strain of *fabae* as reported in the discussion of that strain.

Empoasca recurvata DeLong. During 1931, detailed life history records were obtained upon 27 pairs of this species, all of the first three generations, except one of the fourth, which produced no offspring. The incubation period ranged from 8 to 23 days, the period of nymphal development from 9 to 29 days, and the preoviposition period ranged from 5 to 35 days. One female lived 127 days and deposited eggs over a period of 92 days. This species has been reared from dahlia from Kansas, Missouri and New York. It has been collected in Kentucky and Tennessee, and was sent from California by Mr. Blanchard in September, 1930. During January to April, 1931, it was the most abundant *Empoasca* in the adult stage at Arlington Farm, where it has been reared from aster, cowpea, potato, sunflower (cultivated), and sweet potato. During late autumn it was quite abundant on chrysanthemums, causing a mottling on the leaves. All attempts to crossbreed this species with other species

[7]Jour. Ec. Ent. 24:361–371.

of *Empoasca* were unsuccessful as follows: 11 attempts with *bifurcata*, 7 with *erigeron*, and 10 with *fabae*.

Empoasca solana DeLong. This species was collected on dahlia in western Missouri and on willow in eastern Kansas and western Kentucky in August, 1930, and on pigweed (*Amaranthus retroflexus*) at Urbana, Illinois, (sent as nymphs by Dr. W. V. Balduf) in October, 1931. Since the receipt of this latter material, this species has been found breeding abundantly on pigweed at Arlington Farm and it has also been reared from Mexican tea[1] and pokeweed. It was also taken in trap light at Knoxville, Tennessee, during 1931. During the summer of 1931 difficulty was experienced in rearing offspring from isolated females in order to procure pure stock for life history studies. This was partly due to a lack of knowledge of the host plant requirements of the species. It fed on cowpea but would not reproduce upon this host. It died promptly when confined to alfalfa but bred abundantly on potato and feebly on *Aster* sp. Only a few life history records were obtained in the insectary before the stock of this species all died. The incubation period ranged from 9 to 17 days. The period of nymphal development ranged from 9 to 11 days. One female lived 88 days in the insectary.

HIBERNATION. *Empoasca fabae* has commonly been reported by various writers to hibernate as an adult in weeds and trash in protected places. All efforts to find this species in the field at Arlington Farm during the past three winters have been unsuccessful although other species of *Empoasca* were commonly found. All attempts to secure hibernation of *fabae* in cages during the same period have been unsuccessful although a variety of protection and food has been provided. Hundreds of adults have been placed in these cages during the months of August, September, and October. Adults of *E. erigeron* were found abundantly on *Erigeron* sp., *Aster* sp., and *Solidago* sp. in sheltered places during the mild winter of 1928–29. A few adults were found March 22, 1929, the date nymphs of this species were first observed hatching in the field. Adults of *E. recurvata* were found during the winter of 1930–31, feeding on tender shoots of wild honeysuckle (*Lonicera japonica*) which was partly covered by dried leaves. *E. bifurcata* has not been found abundantly in hibernation but from the data obtained to date this species probably hibernates much the same as does *E. erigeron*.

Host plants upon which *E. fabae* occurred abundantly late in the autumn have been transplanted to the greenhouse in winter without ob-

[1] *Chenopodium ambrosioides* L. Identified by Oliver M. Freeman of the U. S. Bureau of Plant Industry.

taining any hatching of *E. fabae* from them, although other species of Cicadellidae were obtained in this way. No period of aestivation or diapause has been observed for this insect although there is a definite correlation between temperature and development, within certain limits. A constant temperature of 96° F. prevented oviposition as readily as too low a temperature. A strain of *E. fabae* has been bred in the greenhouse continuously since 1928 without any apparent decrease in its ability to produce offspring or to cause injury to its host plants. A survey in the spring of each year of the possible host plants of this species in the field has revealed no nymphs, although those of *erigeron, bifurcata, recurvata, E. birdii* Goding, and *E. maligna* Walsh have been found. During the past three seasons *E. fabae* was first found in the field as fertile females on alfalfa, appearing May 10 to 16 each year. Only a few adults were found at first, but within a few days many more, including males, were present. Adults continued to increase in numbers in the field on alfalfa, young apple, potato, and beans for several weeks. During 1931, *E. fabae* was found abundantly on potato and alfalfa in southern Virginia before it occurred abundantly at Arlington Farm. Automatic insect migration traps, patterned after the one devised and used in the beet leafhopper work in Utah,[9] were used during 1931 and the results indicated no definite important periods of migration except after the cutting of alfalfa. No definite migration from one host to another was observed except when the host material was removed or when it became too mature and the leafhoppers sought more succulent food plants. *Empoasca fabae* was observed to breed continuously in the field until cold weather destroyed the suitable host material. Hatching has often been observed in late November, even after much of the host plant upon which it occurred had been killed by freezing. It has often been reported that *fabae* breeds abundantly during the winter months on various crops in the Southern States, especially in Florida. Although only negative evidence is offered and it is realized that all possibilities of finding *fabae* overwintering in the North have not been exhausted, it seems probable that the species migrates northward each spring, or at least that it is not present in the vicinity of Arlington, Virginia, during the winter.

[9]Jour. Ec. Ent. 24:757–761.

MUCKLAND POTATO SPRAYING EXPERIMENTS

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ABSTRACT

In an experiment to determine the relative merits of spraying muckland potatoes with bordeaux alone and combined with calcium or lead arsenates, the largest yields were obtained from plants sprayed with lead arsenate and bordeaux mixture. All treatments gave significant increases in yields over unsprayed plants. Wheel injury while less severe than horse, wheel and tank injury combined showed yield decreases below uninjured rows. These decreases in yields due to the spraying operations were more than compensated by the increases obtained as a result of the treatments.

The increasing acreage of potatoes grown on muckland in western New York has stimulated interest in spraying procedures for the protection of this crop. Obviously both the problems and control measures may be expected to be at variance with operations on upland soils. The high organic and moisture content of muckland, the vigorous vine growth, large yields and environmental factors all tend to produce conditions peculiar to this industry. Experiments are being conducted with a view toward formulating a satisfactory muckland potato spraying program. The results of one of these experiments are the subject of this report.

TABLE 1. MATERIALS, DILUTIONS AND RATES OF APPLICATION IN POTATO SPRAYING EXPERIMENT

Materials	Dilutions per 50 gallons	Rates of applications per acre
Bordeaux	5 lbs. copper sulphate 7 lbs. lime	1st application, 65 gallons 2nd application, 75 gallons
Calcium arsenate and Bordeaux	2 lbs. calcium arsenate 5 lbs. copper sulphate 7 lbs. lime	3rd application, 85 gallons 4th application, 95 gallons 5th application, 105 gallons
Lead arsenate and Bordeaux	2 lbs. lead arsenate 5 lbs. copper sulphate 7 lbs. lime	6th application, 115 gallons 7th application, 125 gallons 8th application, 125 gallons 9th application, 125 gallons 10th application, 125 gallons

A three and one-half acre field of Irish Cobbler potatoes uniform in all respects, except for the conditions of the experiment containing 60 rows was divided into six row plats. The three treatments were replicated three times. All data was secured in parallel strips across the plats to permit statistical comparisons. While foliage counts of flea beetle, leafhopper, blight and tip and hopper burn injury were made, only the results of the yields are presented here. The bordeaux mixture used in these experiments was prepared with hydrated lime and small copper sulphate crystals in the proportions indicated in Table 1. The

amounts of spray materials applied varied with the size of the plants but all plats received equal amounts. The applications were made with a four-wheel, horse drawn power orchard sprayer equipped with a special boom having three nozzles to each row. The pressure averaged 300 pounds per square inch for all treatments. To eliminate differences in yields due to feeding by the Colorado potato beetles, all plants including the checks were sprayed once with calcium arsenate. The control plants were also sprayed with water at the time of applications on other plats.

TABLE 2. SUMMARY OF THE INCREASES IN YIELDS IN BUSHELS PER ACRE OF TREATMENTS AT SIDE OF TABLE OVER TREATMENTS AT TOP WITH THE SIGNIFICANCES OF THE INCREASES

	Check	Calcium arsenate and Bordeaux	Bordeaux 5–7–50
Lead arsenate and Bordeaux	141.74	83.84	74.34
Significance	5.03	2.97	2.63
Bordeaux 5–7–50	67.70	9.50	——
Significance	2.40	.337	——
Calcium arsenate and Bordeaux	57.90	——	——
Significance	2.05	——	——

TABLE 3. INCREASE OR DECERASE IN YIELD OF INSIDE, MIDDLE, AND OUTSIDE ROWS OVER OR UNDER EACH OTHER IN EACH TREATMENT TOGETHER WITH THE SIGNIFICANCE OF THE FIGURES

Treatment	Row 1 over row 3	Row 1 over row 2	Row 2 over row 3
Calcium arsenate and Bordeaux	9.16	44.93	35.77
Significance	.32	1.59	1.27
Lead arsenate and Bordeaux	—17.70	—101.46	—83.76
Significance	.63	3.60	2.97
Bordeaux 5–7–50	66.37	63.36	—3.01
Significance	2.35	2.24	.11
Check	20.30	36.21	15.91
Significance	.72	1.28	.56

Potato flea beetles (*Epitrix cucumeris* Harris) were more numerous than any other destructive forms altho leaf hoppers (*Empoasca fabae* Harris) were abundant on the vines from July 15 to the end of the season. Early blight (*Alternaria solani*) caused some damage to leaves. Late blight (*Phytophthora infestans*) was of no significance during the past year.

Yield results presented in Tables 2 and 3 were obtained by weighing the potatoes from every plat at digging time. The data has been handled according to the method of Engledow and Yule in The Empire Cotton Growing Review, volume 3, numbers 2 and 3, 1930.

A comparison of the yields in Table 2 indicates that all of the treated plants gave increased yields over the unsprayed which were significant. The largest increase, 141.74 bushels, with the lead arsenate and bordeaux

plats while the smallest increase was obtained from plants sprayed with calcium arsenate and bordeaux. The increased yield of bordeaux over bordeaux and calcium arsenate was not significant.

Injury to vines as a result of spraying is of considerable interest. For purposes of comparison regarding sprayer injury the figures in Table 3 were compiled. Row one received no injury, row two received injury from sprayer wheels and row 3 received horse, wheel and tank injury. In all cases except the lead arsenate plats the outside uninjured rows outyielded inside rows. In general the injury resulting from the passage of wheels and horses over vines was considerably less than where horses, tank and wheels passed over the plants altho the differences were not significant. The reversal of expected results in the cases of those plants sprayed with lead arsenate and bordeaux is apparently inexplicable. It seems evident that there is enough injury incurred in potato spraying operations to warrant further studies in modifying the methods of applying spray materials.

STUDIES OF POTATO TUBER DEFECTS IN WESTERN NEW YORK

By W. A. RAWLINS, *Ithaca, N. Y.*

ABSTRACT

The characteristic feeding scars produced by the various forms is discussed together with the results of the first year's survey of the distribution and prevalence of these injuries in 8 Western New York Counties.

Western New York produces annually about one-third of all the potatoes and fully a half of all the certified seed grown in the state. The recent introduction of the potato grading law and greater competition from other potato producing areas has stimulated interest in the quality of potato tubers produced in this region. Before estimates of the distribution and prevalence of injuries caused by insects and diseases could be obtained it was necessary to determine the characteristics of the injuries produced by the various forms. The present paper attempts to delineate the results of studies of the types of feeding scars produced by the more important forms together with the outcome of the first year's survey.

There are apparently three types of injury to potato tubers caused by wireworms. These various injuries may be classified according to the period of feeding as related to the development of the tubers. Early wireworm injury, resulting from activity of the larvae when potatoes are

small, is distinguished by deep, funnel-shaped, or large shallow cavities in the mature tubers. This injury shows little or no disease infection, the scars are healed over and the tuber is usually badly misshapen. The second type which occurs before potatoes mature, is commonly called "pitting." This deformity is manifest as deep or shallow pits the diameter of which depends upon the sizes of larvae which make the burrows. The skin around the entrance holes becomes cracked, discolored and depressed as a result of infection with Rhizoctonia and other organisms. This corky core or tunnel can be removed intact upon boiling the potato. Late wireworm injury occurs mostly when tubers are mature and consists of a burrow made by entering larvae. This late feeding may or may not become infected but most commonly infection does not result in the development of a wide corky ring around the burrow.

Large numbers of larvae of the potato flea beetle were found tunneling in growing tubers. Surface feeding, just below the epidermis resulted in long, narrow serpentine channels formed by the rupturing of the epidermis. Where tubers were entered a corky skin forms which may become infected. These injuries are not noticeable externally at harvest time.

Larval feeding of white grubs usually appears as large open cavities in the bottoms of which are characteristic small ridges. This injury is too commonly recognized to need extensive discussion.

Snail or slug injury results in extensive feeding cavities which usually completely destroy the tubers. The cavities present several recessed areas with considerable over-hanging, withered epidermal tissue.

At least two species of millipedes feed upon potato tubers producing comparatively shallow, small, clean cavities with little or no over-hanging epidermal tissue. In severe cases of injury a large proportion of a tuber may be eaten away.

During the past year larvae of *Sciara* sp. and *Pnyxia scabei* Hopk. have been found feeding in potato tubers. In some cases injury apparently occurred on normal, healthy tubers and in others the feeding was associated with potato scab, millipede or wireworm feeding. In every case the cavities resulting from larval feeding were filled with a dark granular frass. Externally the only indications of injury were small entrance holes surrounded by a large dark area which represented the excreted material below showing thru the epidermis of the tuber. Many of these injuries could not be definitely determined until the tubers were cut open and examined.

From October 5 to 17 a survey of the amount and distribution of these injuries was conducted in eight counties of western New York. Over

twelve thousand tubers from 105 farms were examined, the injuries counted, classified and recorded. In making the counts on each soil type at each farm, 20 potatoes at 5 different stations were selected at random. A complete record of the elevation, soil type, hydrogen ion concentration, fertilizer practices, rotation systems, and other possible contributing factors was also obtained. All of the possible correlations have not as yet been completed but of those summarized there are some interesting relationships. A correlation of scab with millipede feeding gave an r value of .3362 with Ór = .0799, indicating a high significance. Similarly gnat injury had an r value of .3859 (Ór = .07624) when correlated with the presence of scab. These values tend to prove an association of these injuries but more complete records should be obtained before definite statements may be made.

The results of the survey, presented in the summary table indicate that wireworms are most important in the production of potato tuber injuries in the region surveyed. Moreover the character of wireworms injury is such as to result in more severe losses than such defects as scab or Rhizoctonia. Gnats and millipedes were more numerous in the northern and eastern counties which in general are lower in altitude. Injuries caused by white grubs, snails and flea beetle larvae were not extensive enough to warrant consideration.

Determinations of the characteristic scars on potato tubers produced as a result of the activities of insects and other destructive organisms facilitated a survey of the prevalence and distribution of these pests in western New York. Wireworms, millipedes and two species of gnats were the most common causes of potato tuber blemishes. Wireworm injury was abundant in all but three of the eight counties surveyed. Conditions which favored the development of scab seemed to be associated with increased injury by millipedes and gnats.

SUMMARY TABLE SHOWING THE PERCENTAGES OF POTATO TUBERS AFFECTED BY THE VARIOUS INSECTS AND DISEASES IN A SURVEY AT DIGGING TIME IN WESTERN NEW YORK

County	No. of samples	Average Percentages							
		Clean	Scabby	Rhizoctonia	Wireworms alone	Wireworms pits	Gnats	White grubs	Millipedes
Wyoming..	23	46.5	4.5	28.1	19.1	6.4	7.7	6	4.2
Alleghany .	13	62.4	2.2	20.5	8.7	1.7	5.6	1.3	1.8
Steuben...	26	53.5	3.6	17.1	16.4	3.5	7.6	.7	14.6
Erie.....	12	52.3	—	13.5	19.9	1.2	8.4	.4	6.1
Genesee...	11	48.6	24.2	19.1	7.9	.7	11.9	0	11.9
Monroe....	18	27.7	17.4	16.8	40.9	2.0	15.3	.3	18.2
Ontario....	10	30.0	25.7	21.1	16.7	—	30.7	.8	24.3
Onondaga .	10	38.4	24.4	20	8.8	.1	19	.1	22.9
General av.	123	45.7	11.3	17.5	18.7	2.6	11.9	.5	12.2

THE INFESTATION OF THE CORN EAR BY *CHLORIDEA OBSOLETA* FAB. IN REGARD TO TIME OF SILKING

By L. P. DITMAN, *University of Maryland, College Park, Md.*

ABSTRACT

Observations show that the rate of infestation of the ears was greatest between the second and eighth days after silking, on three plantings of corn in 1931.

Observations on oviposition by the corn earworm have been made by several workers, and in all cases more eggs have been found to be laid on silks than any other part of the plant. From this fact it may be assumed that the major portion of the infestation of the ears arises from these eggs, and further, that most of the larvae enter the ear by way of the silk. However, to base the timing of control measures on such an assumption would be dangerous since eggs are laid on the corn plants from the time they are a foot high until after the ears are fully formed, probably as long as the stalks remain green.

In 1929 experiments were conducted on six plots of sweet corn to determine the effect of desilking[1] at intervals of one to three days. The infestation in desilked plots varied from 13% to 58%, with an average of 40% infestation, as compared with 58% infestation in the check plot. In other words, the average infestation of desilked plots was 69% of that in the check. In these desilking experiments conditions were such that eggs which were ordinarily laid on the silk played no part in the infestation.

In 1930 the writer checked on the infestation of corn ears at different intervals, from young ear buds before silking to ears 15 days after silking. These results have been published.[2] Two interesting facts were observed at this time: (1) that slightly over 50 per cent of young ears were infested with corn earworms by the time the silks appeared, (2) that over 30 per cent of the young ears were infested by very young larvae entering the ears by eating directly through the husks. These records were made on a late planting of corn during one of the driest summers with the heaviest infestation of corn earworm in years.

In order to check further on the time of infestation of corn by the corn earworm under conditions of a more normal season, three plots of corn were planted during the summer of 1931, a planting of Golden Bantam the first of May, and two plantings of Country Gentleman, one the middle of May and one the first part of June. This was done in order to get three different degrees of infestation by the corn earworm.

[1]Cutting off the silks at the tips of the husks.

[2]Md. Agri. Exp. Sta. Bul. No. 328.

The first planting reached 64.5 per cent, the second planting 77.5 per cent and the third 98.1 per cent. Twenty-six hundred ears were labeled, the records of 2256 ears being complete, 890 on the first planting, 839

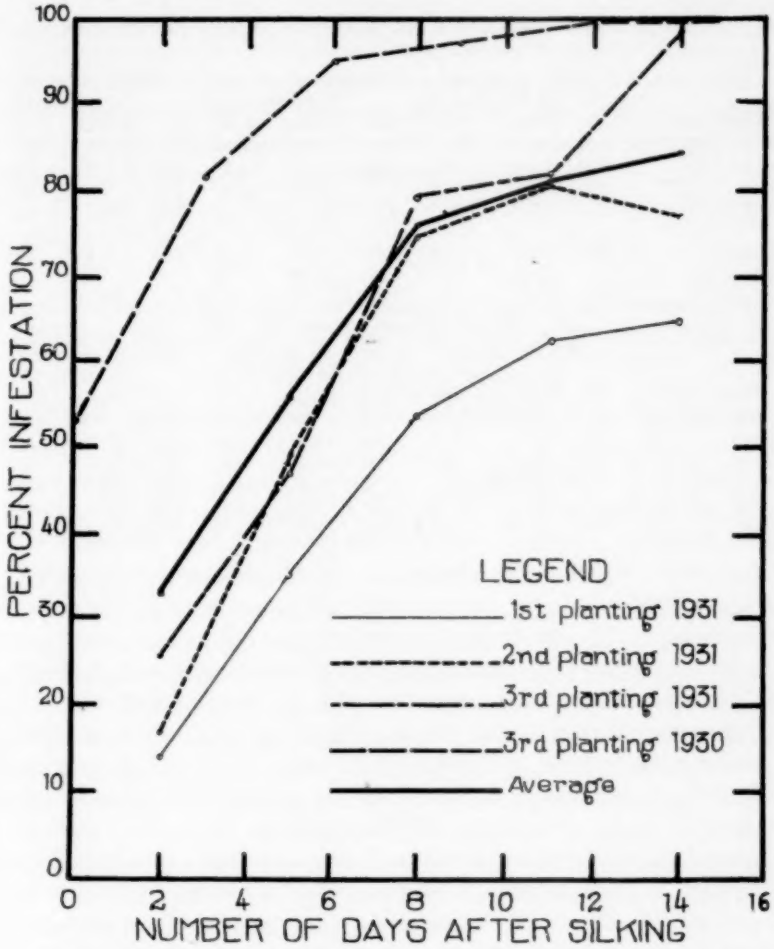


FIG. 36.—Graph showing the rate of infestation of four plantings of corn during 1930 and 1931 in regard to the time of silking of the ears.

on the second, and 527 on the third. The ears were watched daily until they silked, the date of silking being then recorded. In each planting the ears labeled were divided into five groups, one group being examined 2 days after silking, another 5 days, etc., up to 14 days after silking. A complete record of infestation of each ear was kept as to whether

it was infested through the tip (or silk) or through the husk, and whether it was infested either way by a young, old, or both young and old larvae.

TABLE 1. SHOWING THE NUMBER OF EARS INFESTED THROUGH THE HUSK BY YOUNG AND OLD LARVAE

Days after silking examined	First planting No. ears	First planting % infested by Young larvae	First planting % infested by Old larvae	Second planting No. ears	Second planting % infested by Young larvae	Second planting % infested by Old larvae	Third planting No. ears	Third planting % infested by Young larvae	Third planting % infested by Old larvae
2 days	193	0.0	1.6	168	1.8	0.0	105	6.7	1.9
5 days	193	1.0	2.6	179	3.9	0.6	109	1.8	0.9
8 days	171	0.6	3.5	177	6.8	1.7	100	4.0	0.0
Total	557	0.5	2.5	524	4.2	0.8	314	4.1	1.0

TABLE 2. SHOWING THE NUMBER OF EARS INFESTED THROUGH THE TIP (OR SILK) BY OLD AND YOUNG LARVAE

Days after silking examined	First planting No. ears	First planting % infested by Young larvae	First planting % infested by Old larvae	Second planting No. ears	Second planting % infested by Young larvae	Second planting % infested by Old larvae	Third planting No. ears	Third planting % infested by Young larvae	Third planting % infested by Old larvae
2 days	193	11.9	1.0	168	14.3	0.6	105	16.2	1.9
5 days	193	30.6	2.1	179	44.1	3.4	109	45.0	0.9
8 days	171	53.2	1.2	177	70.1	4.0	100	88.0	1.0
11 days	164	57.9	1.2	178	80.2	0.0	109	91.7	0.0
14 days	169	60.4	.6	137	76.6	0.0	104	97.1	1.0

There was but little bud and tassel injury in any of the three plantings and there was practically no infestation of young ears at the time the silks appeared. The total infestation was found to increase most rapidly between the second and eighth days after silking in all three plantings of corn. The rate of the total infestation of each planting is shown in Fig. 36. The average trend for all plantings is also shown. After the finding of the relatively large percentage of young ears infested through the husk by young larvae, in 1930, it was of particular interest to see the extent of this type of injury in this year's plots. In the first planting it was found that only three young larvae had entered through the husks in the first 557 ears examined over a period of two to eight days after silking, while in the first 524 ears of the second planting 22 young larvae had entered through the husk, and in the third planting 13 young larvae entered through the husk in the first 314 ears examined. A detailed account of the infestation of corn earworm in all three plantings is shown in Tables 1 and 2.

Incidentally lead arsenate was applied to a plot of each planting, the timing of the first application being based on the above observations. Nine applications of lead arsenate without a carrier were applied on each plot with a rotary hand duster. The results were not encouraging.

Only 60 per cent control was obtained in the first planting, 58 per cent in the second and 35 per cent in the third.

SUMMARY

1. Observations during 1931 at College Park showed that the rate of infestation by the corn earworm was greatest between the second and eighth days after silking of the ears. However, when the corn earworm is exceptionally abundant heavy infestation may be expected before this time, as indicated by the observations of 1930.

2. Further tests of lead arsenate did not give sufficient control to recommend its use.

PLANT BUGS AS PESTS OF PEAR AND OTHER FRUITS IN THE HUDSON VALLEY

By F. G. MUNDINGER and P. J. CHAPMAN,[1] *Experiment Station, Geneva, N. Y.*

ABSTRACT

Late in August *Acrosternum hilaris*, *Euschistus euschistoides*, and *E. variolarius* were observed in pear orchards thruout the Hudson valley. They were found to attack several varieties of pears as the fruit was maturing, resulting in serious commercial damage.

On August 21 large numbers of brown stink-bugs were observed on Beurre Bosc pears in an orchard at Athens, N. Y. The next day these insects, which were later determined as *Euschistus euschistoides* (Voll) and *Euschistus variolarius* (Pal. de Beauv.), together with both nymphs and adults of *Acrosternum hilaris* (Say), were seen feeding on Bartlett pears in orchards at Red Hood and Germantown. In subsequent surveys to determine the distribution of the insects no difficulty was experienced in locating pear orchards infested with all of the above mentioned species, and in addition three other species; namely, *Euschistus tristigmus* (Say), *Podisus maculiventris* (Say), and *Coenus delius* (Say) were found in some orchards. A Kieffer orchard at Stuyvesant Falls was so thickly populated with *A. hilaris* that one jarring of a tree brought down scores of bugs, mostly adults. In this same location a field of sweet corn was found heavily infested with both nymphs and adults of this species. It was also observed feeding on apple, altho not very commonly, while *Euschistus* sp. were seen on peaches in several orchards.

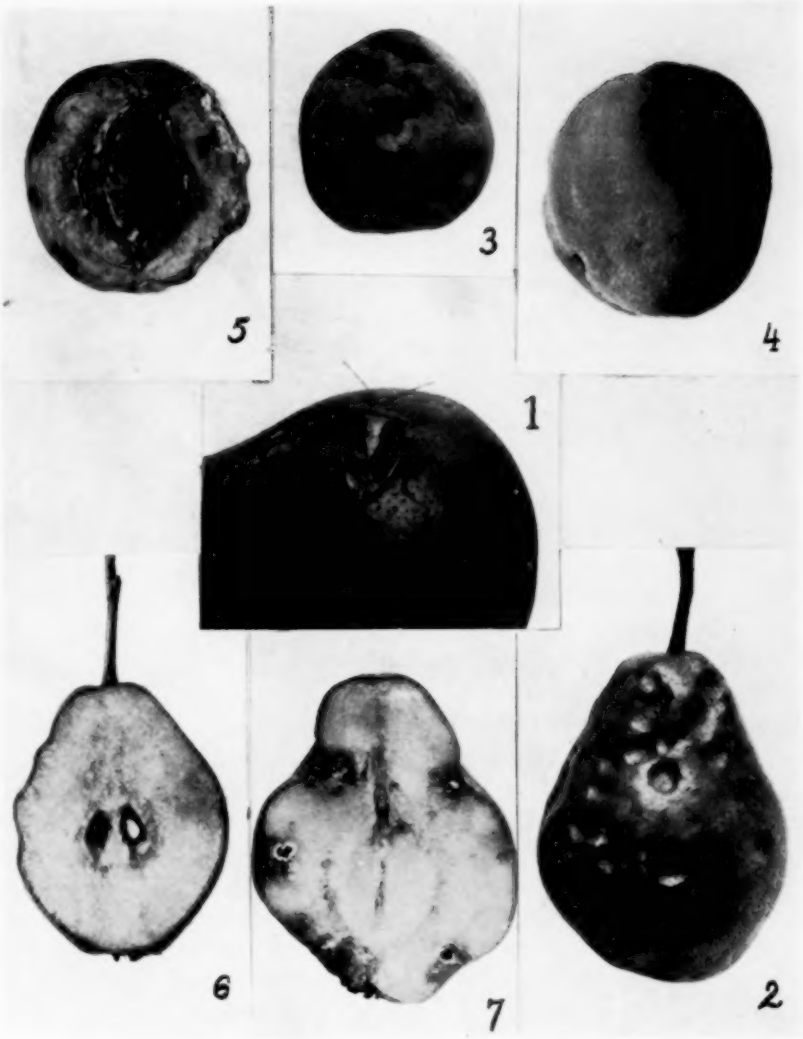
The most northern limit at which the stink-bugs were noticed attacking pears was at Crown Point, N. Y., Essex county. From here the

[1]Dr. C. J. Drake kindly identified the several species discussed in this paper.

area of infestation extended south thru the Hudson valley. The southern limit for this season is not definitely known, but a record cited later in this paper bears testimony to the presence of the bugs on Long Island. Concurrently with the discovery of these insects in large numbers in many plantings, Bartlett pears in various orchards began to show surface blemishes somewhat similar to hailstone injury. Shallow depressions or dents of varying size and shape appeared on the fruits. While some pears had but one such mark, others were so badly dented that they had no commercial value. Peaches were found with the same type of injury, and later a few varieties of apples. With the advance of the season the injury became more conspicuous and buyers were unwilling to accept the damaged fruit. One pear grower discarded 95 per cent of his crop because of fruit deformities, while other growers thruout the valley suffered considerable losses because of the reduced market value.

A prominent fruitgrower at Hudson, N. Y., reports that his crop of pears has shown more or less of the injury so common in 1931 for the past ten years. Other fruitgrowers also appear to have noticed the trouble in past years, and some have even suspected that stink-bugs were responsible for the deformities. Of interest in this connection are some unpublished observations by Professor C. R. Crosby, Extension Entomologist of New York. In 1918 pears were received from Columbia county which, according to Professor Crosby, were similar or identical with those damaged by the stink-bug in 1931; in fact in a letter to the County Agent he suggested that the injury was probably due to *Nezara hilaris* (Say). The letter also states that injured pears and bugs were seen on Long Island and in Orange county.

The most severe fruit injury was found in the vicinity of woodlands or where the orchard bordered uncultivated land. Varieties of pears found damaged included Bartlett, Clapp Favorite, Beurre Bosc, Kieffer, Seckel, and D'Anjou. It was noticed that the bugs were apparently attracted to the fruit as it ripened. Blocks of the Bartlett variety, for example, near Kieffer were heavily infested, while no bugs were to be found on the later maturing Kieffer. A similar preference was shown for D'Anjou growing near Kieffer. The variety Winter Howe interplanted with Beurre Bosc was not injured, while fruits of the latter showed many dents. The bugs migrated to Kieffer pears later in the season and often caused serious injury. This migration did not occur in cases under observation until after the earlier maturing fruit had been picked, so it is not clear whether the insects attacked the Kieffer because of the absence of more attractive food or because the fruit had



1. Adult of *Euschistus euschistoides;* 2. Bartlett pear, demonstrating the type of injury found on all varieties of pears attacked by the several species of Plant Bugs; 3. One type of feeding injury on peach; 4. Type of feeding injury on peach similar to that on pears generally; 5. A peach halved, to show injured areas just under the skin; 6. A Kieffer pear section showing early type of feeding injury; 7. Bartlett pear section showing later type of feeding injury.

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then attained a satisfactory degree of maturity. Possibly both factors were concerned.

During our early observations on the habits of these insects, the bugs were not easily disturbed and it was not difficult to watch them in the act of feeding. In this operation only the fine, hair-like stylets are forced thru the skin and into the tissue of the fruit. In some instances the stylets appear to penetrate the fruit to a depth of a quarter of an inch. When feeding on ears of sweet corn the bugs often pierced the husk to reach the kernel. The stylets may remain inserted for several minutes while feeding, and upon withdrawal a small droplet of moisture would sometimes appear at the point of puncture. After a few days, depending probably on the condition of the fruit and other unknown factors, the area about the puncture collapses and becomes depressed. On removing the skin over these places, irregular white patches of pithy material could be seen. If the injured region were cut thru perpendicularly to its surface it sometimes appeared honeycombed. One large cavity was usually prominent among many smaller ones, indicating that the juice had disappeared from a multitude of cells, causing them to collapse.

While the stink-bugs were commonly found feeding and the characteristic injury appeared in many locations which were known to be infested, the evidence did not appear complete enough to designate definitely that these insects were the agents. Accordingly, an attempt was made to secure positive proof by caging the various species of bugs found, on uninjured fruit. The cages were cylinders made of fly-screening with cloth sleeves at each end so that they could be slipped over a small branch and tied in position. A check cage for enclosing a large branch having many fruits was similarly constructed. From August 23 to October 10 sixteen cages in all were in operation. Several varieties of pear were screened, including Bartlett, Kieffer, and Bosc. Three known species of stink-bugs were used in the tests. One cage contained nymphs only. Most of the cages were supplied with several insects, and as they died more individuals were introduced. One cage containing 19 bugs was placed over two McIntosh apples. The data obtained from the cages over Kieffer pears are shown in Table 1. On examining the table it will be noted that practically every pear in the cages subject to insect attack showed one or more injuries, and it should also be noted that the majority of the fruits dropped prematurely. Of the forty-one pears in the check cage and protected from attack by the insect, not one showed injury. Every pear was free from depressions and had hung tightly to its spur with the exception of one which fell, due to accident. From

these facts it appears to be definitely established that the injury so commonly observed during the past season was caused by various species of stink-bugs as listed.

TABLE 1. RECORD OF STINK-BUG ACTIVITY IN OBSERVATION CAGES

Number cage	Number bugs	Species	Number pears	Number fruit injured	Number feeding marks
1	11	Euschistus sp.	4	3	9
2	10	A. hilaris	5	5	44
3	4	A. hilaris (nymphs)	4	1	10*
4	5	Brochymena (?)	2	0	0
5	9	A. hilaris	3	4	61
6	15	A. hilaris	5	5	47
7	9	A. hilaris	3	2	55
8	11	A. hilaris	4	4	101
9 Check	0		41	0	0
			Apples (McIntosh)		
10	19	A. hilaris and Euschistus sp.	2	2	19

*The nymphs died a few days after being placed in the cages.

Of the two prominent species *A. hilaris* was the more common. The *Euschistus* sp. appeared to favor the Bosc pear and the ripening peaches, while *A. hilaris* seemed most attracted to the green fruits of such varieties as Bartlett and Kieffer. Bartletts injured by *A. hilaris* showed the depressions four days after the feeding, while Boscs and Kieffers showed injury in six to eight days after feeding.

With respect to the relative susceptibility of the different fruits, the greatest damage was done to the pear crop. Peaches and apples in general suffered no commercial loss.

STUDIES OF THE STRIPED AND SPOTTED CUCUMBER BEETLES

By F. G. BUTCHER, *Ithaca, N. Y.*

ABSTRACT

In experiments testing relative efficiency of copper sprays and dusts both with and without calcium arsenate, the dusted plats in general gave the greatest increase in yields. The addition of the poison substantially increased yields over plats treated with copper lime-mixtures only.

The necessity of more adequate informatinn regarding control methods for the striped and spotten cucumber beetles arose as the result of serious losses to the western New York pickle crop. A series of investigations were started in the summer of 1930 in Orleans County, where approximately 2000 acres of land are devoted to cucumber grow-

ing, This preliminary report presents some of the activities and results obtained in conducting these investigations during the past two seasons.

The primary aim of the field work for the summer of 1930 was to test the relative effectiveness of the two standard treatments as practised by the growers, i. e., the effectiveness of sprays vs. dusts. In all cases the spray used was a 4–4–50 Bordeaux mixture to which was added 2 pounds of calcium arsenate, and the dust was a 15–73–12 copper-lime-calcium arsenate mixture. Three representative fields were selected for the experimental work and these were divided into plats of 3 or 4 rows each, the dust plats alternating with the spray plats. In every case the treatments were replicated either 3 or 4 times.

However, due to extremely adverse weather conditions and a very light infestation of beetles with a consequent small amount of damage, conclusive results were not obtained from the season's work. Extremely low yields of poor quality fruits were encountered so that results were anything but gratifying and few conclusions could be drawn from them.

During the past season, the same general plan of work was continued, but both the spray and dust treatments were tested with and without the addition of calcium arsenate. The plats were laid out as described above and were replicated 3, 5, and 6 times respectively in the three experiments.

In all the experiments the dust treatments were applied with a rotary hand duster, but the sprays were applied in a different manner in each experiment. The mixture used was a 3–4–50 Bordeaux in all experiments and in one set of plats of each experiment 2 pounds of calcium arsenate was added. In all experiments a 20–80 copper-lime dust was used in one set of plats and in the remaining plats a copper-lime-calcium arsenate mixture was applied.

Experiment I included a field of approximately 1¼ acres in size, with the planting made in hills, 4½ x 4½ feet. Each plat consisted of 3 rows of 60 hills each and the treatments were replicated 3 times. Three check plats of similar size were left untreated. Seven applications of dusts were made thruout the season, the plants being well covered at each application. A total of approximately 150 pounds of each dust per acre was used. The spray was applied with a power sprayer, using about 150 pounds pressure and a 2 nozzle gun, in 7 applications using a total on each set of plats of approximately 500 gallons of material. Yields were taken at the time of regular pickings from one-tenth of each plat, the areas being comparably located, and all fruits were picked, regardless of quality.

As may be seen from the table (Table 1) all treatments gave an increase over the checks of high significance, the figures being treated statistically according to the method of Engledow and Yule in the *Empire Cotton Growing Review*, Vol. III, Nos. 2 and 3, 1930. The copper-lime dust containing poison gave much better results than any other treatment, but good increases in yields over the checks were also obtained with the copper-lime dust and the Bordeaux spray containing poison.

TABLE 1. GAIN IN YIELD IN POUNDS OF TREATMENTS AT SIDE OF TABLE OVER TREATMENTS AT TOP WITH THE SIGNIFICANCE OF THE DIFFERENCES INDICATED

Treatment	Check	Bordeaux spray	Bordeaux and calcium arsenate spray	Lime-copper dust
Lime - copper - calcium arsenate	125.3	102.8	51.9	37.0
Significance	25.42	20.77	10.48	7.47
Lime and copper	88.3	65.8	14.9	—
Significance	17.84	13.30	3.01	—
Bordeaux and calcium arsenate	73.4	50.9	—	—
Significance	14.83	10.29	—	—
Bordeaux	22.5	—	—	—
Significance	4.54	—	—	—

In Experiment II, a field of slightly over 1½ acres was used. The plants were in hills 4 x 6 feet apart. Each plat contained 116 hills, and the plats, including checks of a similar size were replicated 5 times. All applications were made by hand, using the same rotary duster as in Experiment I, and a good knap-sack sprayer for the spray treatments. Six applications of both dusts and sprays were made, the amount of dust per acre being about the same as in the first experiment, but only 200 gallons of spray per acre were used. The entire plats were used in obtaining yield data, but an attempt was made to pick only marketable fruits.

TABLE 2. GAIN IN YIELD IN POUNDS OF TREATMENTS AT SIDE OF TABLE OVER TREATMENTS AT TOP WITH THE SIGNIFICANCE OF THE DIFFERENCES INDICATED

Treatment	Check	Bordeaux spray	Bordeaux and and calcium arsenate spray	Lime and copper dust
Lime - copper calcium arsenate	299.1	185.8	110.6	100.7
Significance	6.28	3.90	2.32	2.11
Lime and copper	198.4	85.1	9.9	—
Significance	4.16	1.78	.21	—
Bordeaux and calcium arsenate	188.5	75.2	—	—
Significance	3.96	1.58	—	—
Bordeaux	113.3	—	—	—
Significance	2.38	—	—	—

Here again all treatments gave significant increases over the checks, also the copper-lime dusts containing poison was significantly better than the other treatments (Table 2). Slightly increased yields of the other treatments over each other occurred, but these increases have a low significance.

Experiment III was conducted with considerably larger plats, using a field slightly in excess of 3½ acres. The vines were planted in hills, 4 x 6 feet. Each plat contained 3 rows of 145 hills each. The same dusts as in other experiments and in similar amounts were applied by hand. The sprays were applied with a 3 row boom with 3 nozzles per row attached to a power sprayer, 6 applications being made, using a total of about 500 gallons per acre.

TABLE 3. GAIN IN YIELD IN POUNDS OF TREATMENTS AT SIDE OF TABLE OVER TREATMENTS AT TOP WITH THE SIGNIFICANCE OF THE DIFFERENCES INDICATED

Treatment	Check	Bordeaux spray	Bordeaux and calcium arsenate spray	Lime and copper dust
Lime - copper calcium arsenate	24.4	26.1	17.0	4.3
Significance	2.43	2.27	1.58	.40
Lime and copper	20.1	21.8	12.7	——
Significance	1.87	2.03	1.18	——
Bordeaux and calcium arsenate	7.4	9.1	——	——
Significance	.69	.85	——	——
Check	——	1.7	——	——
Significance	——	.16	——	——

Two sets of comparable yield figures were taken from each plat, each set comprising about 1/36 of the entire plat, thus giving 6 sets of figures for each treatment. An examination of these data statistically treated (Table 3) shows us that both dust treatments were more successful than the spray treatments with but little significant difference between the two. However, it should be noted that the dust containing poison again gave the high figures. In no case did the spray treatments give increases of any significance over the checks. This is probably due to the fact that the boom did not give a uniform coverage of all parts of the plants, especially in the later applications. However, with more careful adjustment and operation it seems probable that a boom may be successfully used in cucumber spraying. In this experiment cucumber mosaic was prevalent to a considerable extent, and consequently very low yields were obtained from all plats.

SUMMARY

In experiments to determine the relative efficiency of copper sprays and dusts with and without calcium arsenate in preventing injury to

cucumber plantings by striped and spotted cucumber beetles, dusted plants in general gave the greatest increase in yields. The addition of calcium arsenate substantially increased yields over plants treated with copper-lime mixtures only. Hand treatments were not only more effective but were more economical from the standpoint of amounts of materials used than power dusters and sprayers. Modifications of machinery for applying materials are necessary before efficient protection is obtainable. Under the conditions of these experiments the highest yields in every case were obtained by applying a dust containing lime, copper sulfate and calcium arsenate.

STUDIES OF THE ONION THRIPS

By F. B. MAUGHAN, *Ithaca, N. Y.*

ABSTRACT

In tests for control of the onion thrips, all treated plants showed substantial and significant reductions in numbers of thrips over untreated plants, but the differences between treatments while considerable in some cases were not of a high degree of significance. Nicotine preparations were most effective in general, with kerosene, pyrethrum products, naphthalene and copper sprays or dusts giving high degrees of control.

The onion crop of New York State, valued at approximately two and a half million dollars annually, is subject to substantial losses occasioned by mid-summer attacks of the onion thrips, *Thrips tabaci* (Lind). While the severity of the damage occasioned by these insects in any one year depends largely upon local weather conditions, the pest is of sufficient importance each year to warrant consideration. Because of the conflicting statements regarding satisfactory control measures, the necessity for more economical methods of preventing losses and the necessity for information regarding local conditions, a series of investigations were started in Orange County, N. Y., in May, 1930. These studies were primarily concerned with preventing thrip injury to onions grown on muck lands. The present report represents some of the results secured from experiments with insecticides.

FIELD EXPERIMENTS IN 1930. In selecting fields for experimental work, an attempt was made to secure plantings typical of the muckland onion areas. The experiments were widely separated and each field represented a distinct type of ecological environment. The plats consisted of four rows each and all plats were replicated three or four times to compensate for variations in soils, degree of infestation and other environmental factors.

In taking records count areas were established in the middles and near the ends of all plats. These areas were arranged in parallel strips across all plats in an experiment so that the data obtained might be statistically comparable. The numbers of live thrips on equal numbers of plants in each plat were recorded within 24 hours after each application. Data thus obtained was summarized for the season and the relative efficiencies of the various materials has been presented as the decrease in numbers of thrips on treated plats compared to check plats. The error indicated with each reduction is the standard error.

TABLE 1. MATERIALS, DILUTIONS AND REDUCTIONS IN NUMBERS OF THRIPS PER PLANT PER SEASON IN EXPERIMENT 1, 1930

Materials	Dilution per 50 gallons	Thrips per plant average No.	Reduction due to treatment	Error
Nicotine dust.....	2.70 per cent	11.56	45.32	9.32
Nicotine.....	½ pint	16.73	41.03	8.9
Soap.....	4 pounds			
Koloform dust.....	400 pounds per acre	19.52	35.23	5.26
Koloform spray.....	10 pounds	28.10	26.60	4.55
Volck oil.....	4 gallons	28.36	25.93	9.8
Kolodust.....	400 pounds per acre	37.31	17.05	2.89
Check, no treatment		53.82		

In Experiment 1, which was conducted in a field adjacent to a planting of onion sets, the nicotine sprays and dusts were generally most effective. (Table 1). All of the materials, however, showed a significant reduction in numbers of thrips below the number on untreated plants. All of the materials in this experiment were applied by hand. The plats were 144 feet long and four rows wide.

In Experiments 2 and 3 the spray materials were all applied with a Bolen's tractor power sprayer attachment, having two nozzles to each row. The spray was forced into the onion tops at an angle of about 45 degrees under 150 pounds pressure. All the dusts were applied with a rotary hand duster. The plats in both of these experiments were 330 feet long and 4 rows wide.

The results in both of these experiments (Tables 2 and 3) seemed to substantiate the findings in Experiment 1 as far as nicotine preparations were concerned. It should be noted, however, that the numbers of thrips on untreated plants were so few that the same results might not hold where severe infestations occurred. The light infestation may have been largely due to the absence of any onion set plantings near either of these experiments.

FIELD EXPERIMENTS IN 1931. The same general plan of procedure was employed in 1931 as in the preceding year with regard to both the lay-

out of plats and taking of data. To test the mechanical effects of spraying operations, some of the plants in the check plats were sprayed with water. Plants so treated not only showed no reduction in numbers of thrips but in most cases substantial increases occurred. In presenting

TABLE 2. MATERIALS, DILUTIONS AND REDUCTIONS IN NUMBERS OF THRIPS PER PLANT PER SEASON IN EXPERIMENT 2, 1930

Material	Dilution per 50 gallons	Thrips per plant average No.	Reduction due to treatment	Error
Nicotine sulfate 40% Penetrol	½ pint 1 quart	3.86	7.46	2.32
Hydrated lime dust	250 pounds per acre	3.85	7.41	2.60
Nicotine sulfate 40% Hydrated lime	½ pint 5 pounds	2.85	6.66	1.62
Kolodust	400 pounds per acre	5.03	6.12	1.58
Lead arsenate Wheat flour	4 pounds 5 pounds	6.67	4.72	1.08
Check, no treatment		10.52		

TABLE 3. MATERIALS, DILUTIONS AND REDUCTION IN NUMBERS OF THRIPS PER PLANT PER SEASON IN EXPERIMENT 3, 1930

Materials	Dilutions per 50 gallons	Thrips per plant average No.	Reduction due to treatment	Error
Nicotine Penetrol	½ pint 2 quarts	2.32	11.14	2.59
Nicotine Soap	½ pint 6 pounds	4.59	10.34	2.62
Fluo dust Hydrated lime	25% 75%	5.19	9.37	1.19
Dry lime sulfur spray	7¼ pounds	7.44	9.12	1.73
Copper dust	25%–75%	5.41	9.05	2.17
Bordeaux spray	4–4–50	7.51	6.95	2.5
Check		14.56		

the data the method of Engledow and Uhle in *Empire Cotton Growing Review*, Vol. 3, Nos. 2 and 3, 1930 has been followed. This procedure admits of direct comparisons between treatments as well as between treated and untreated plants.

Several materials were tested for the purpose evolving a more economical control for the insects. There were 3 applications in all experiments except numbers 1 and 2 which received 4 applications. Table

TABLE 4. A LIST OF MATERIALS, THEIR DILUTIONS AND RATES OF APPLICATION IN 1931 EXPERIMENTS

Materials	Dilutions per 50 gallons or pounds	Rate of application pounds or gallons per acre	Toxicity to onion plants
	Experiment 1		
Kleenup	2 per cent	150	slight
Lethane	½ gallon	150	none
Scalecide	1 per cent	150	none
Sulfocide	1 quart	150	slight
Dry lime sulfur	8 pounds	150	slight
Kayso	2 pounds		
Nicotine	½ pint	120	none
Soap	6 pounds		
Sulfuric acid	½ pint	120	none
Soap	3 pounds		
	Experiment 2		
Volck oil	2 per cent	120	severe
Slate dust	75 per cent	150	none
Hydrated lime	25 per cent		
Wettable sulfur	10 pounds	150	none
Kayso	2 pounds		
Hydrated lime dust	none	120	none
Kerosene spray	3 per cent	120	none
Kolodust	none	240	none
Wettable sulfur dust	none	240	none
	Experiment 3		
Dutox dust	2 parts to 4 of hydrated lime	150	none
Diamond oil	2 per cent	150	none
Bordeaux	4–4–50		
Calcium cyanide	1	150	none
Hydrated lime	9		
Blue slate	3	150	none
Lime	1		
Copper dust	20–80 per cent	150	none
	Experiment 4		
Koloform dust	none	250	none
Hydrated lime	none	150	none
Red slate	75 per cent	250	none
Lime	25		
Wettable sulfur	none	250	none
Dust			
Blue slate	75–25 per cent	250	none
Kolodust	none	250	none
Copper dust	20 per cent	250	none
Lime	80 per cent		
Dutox	25 per cent	250	none
Lime	75 per cent		
Nicotine dust	2.70 per cent	150	none
Calcium cyanide	10 per cent	250	none
Lime	90 per cent		
Naphthalene flakes	none	250	none

TABLE 4. *Continued*

Material	Dilutions per 50 gallons or pounds	Rate of application pounds or gallons per acre	Toxicity to onion plants
	Experiment 5		
Red Arrow spray	1 pint	125	none
Penetrol	1 quart	125	none
Nicotine	¼ pint		
Crude carbolic acid	3⅓ gallons	125	none
Nicotine	¼ pint	125	none
Soap	4 pounds		

4 gives a summary of the treatments employed in five experiments. All of the treatments were applied with hand sprayers and dusters in the 1931 experiment. The oil sprays in all cases showed some injury to onion tops and there was slight questionable injury in the case of sulfur dusts. None of the injuries noticeably affected yields.

In comparing results in the various experiments it should be noted that the infestation in experiment 1 was very light so that the reductions in this experiment are not highly significant. From July 13 to 15 this experiment was flooded by rains, which doubtless reduced the number of thrips. In general all of the treated plants showed substantial and significant reductions in numbers of thrips over untreated plants but differences between treatments, while considerable in some cases were not of a high degree of significance. Nicotine preparations were most effective in general with kerosene, pyrethrum products, naphthalene, and copper sprays or dusts giving high degrees of control. (Tables 5 to 9 inclusive).

It is apparent from these results that while nicotine sprays and dusts are most effective in reducing the numbers of thrips on onions, there are many materials of diverse character, probably acting as repellents, which may be used to protect onions from the attacks of thrips. The relative merits of various materials need additional investigational work before definite conclusion can be reached.

TABLE 9. REDUCTION IN AVERAGE NUMBER OF THRIPS PER PLANT OF TREATMENTS AT TOP OF TABLE BELOW TREATMENTS AT SIDE OF TABLE, EXPERIMENT 5, 1931

	Nicotine and C.P.O. spray	Nicotine and Penetrol	Red Arrow	Crude carbolic
Check	48.71	48.11	44.96	43.43
Significance	3.64	3.60	3.36	3.25
C. carbolic	5.28	4.67	1.53	—
Significance	.39	.35	.11	—
Red Arrow	3.75	3.15	—	—
Significance	.28	.24	—	—
Nicotine penetrol	.60	—	—	—
Significance	—	—	—	—

TABLE 5. REDUCTION IN AVERAGE, NUMBER OF THRIPS PER PLANT OF TREATMENTS AT TOP OF TABLE, BELOW TREATMENTS AT SIDE OF TABLE, EXPERIMENT 1, 1931

	Nicotine and C.O.P. soap	Kleenup	Sulfuric Acid	Lethane	Scalecide	Dry lime sulfur	Sulfocide
Check	7.21	6.16	5.87	5.79	5.78	5.53	4.53
Significance	2.09	1.79	1.70	1.68	1.67	1.60	1.31
Sulfocide	2.68	1.63	1.34	1.26	1.25	1.00	—
Significance	.77	.47	.38	.37	.37	.28	—
Dry lime sulfur	1.68	.63	.34	.26	.25	—	—
Significance	.48	.18	—	—	—	—	—
Scalecide	1.43	.38	.9	.1	—	—	—
Significance	.41	—	—	—	—	—	—
Sulfuric acid	1.42	.37	.8	—	—	—	—
Significance	.41	—	—	—	—	—	—
Lethane	1.34	.29	—	—	—	—	—
Significance	.39	—	—	—	—	—	—
Kleenup	1.05	—	—	—	—	—	—
Significance	.30	—	—	—	—	—	—

TABLE 6. REDUCTION IN AVERAGE NUMBER OF THRIPS PER PLANT OF TREATMENTS AT TOP OF TABLE, BELOW TREATMENTS AT SIDE OF TABLE, EXPERIMENT 2—1931

	Nicotine and C.P.O.	Kerosene	Volck oil	Wettable sulfur dust	Hydrated lime	Slate dust	Kolodust	Wettable Sulfur spray
Check	41.96	41.02	33.76	32.78	32.32	31.89	31.82	31.80
Significance	7.33	7.20	5.92	5.72	5.64	5.57	5.55	5.55
Wettable sulfur dust	10.16	9.22	1.96	.98	.52	—	—	—
Significance	1.77	1.61	.34	—	—	—	—	—
Kolodust	10.14	9.20	1.94	.96	—	—	—	—
Significance	1.77	1.61	.34	.17	—	—	—	—
Slate dust	10.07	9.13	1.87	.89	.43	—	—	—
Significance	1.76	1.59	.33	.16	—	—	—	—
Hydrated lime	9.64	8.70	1.44	.46	—	—	—	—
Significance	1.68	1.52	.25	—	—	—	—	—
Wettable sulfur spray	9.18	8.24	.98	—	—	—	—	—
Significance	1.60	1.44	.17	—	—	—	—	—
Volck oil	8.20	7.26	—	—	—	—	—	—
Significance	1.43	1.27	—	—	—	—	—	—
Kerosene	.94	—	—	—	—	—	—	—
Significance	.16	—	—	—	—	—	—	—

TABLE 7. REDUCTION IN AVERAGE NUMBER OF THRIPS PER PLANT OF TREATMENTS AT TOP OF TABLE, BELOW TREATMENTS AT SIDE OF TABLE, EXPERIMENT 3

Treatments	Pyrethrum	Copper dust	Bordeaux lead arsenate	Cyanide	Paraffin oil	Dutox spray	Blue slate	Dutox dust
Check	39.74	38.84	36.28	35.48	35.04	33.08	30.21	28.23
Significance	3.95	3.86	3.60	3.53	3.48	3.29	3.01	2.80
Dutox dust	11.51	10.61	8.05	7.25	6.81	4.85	1.98	—
Significance	1.14	1.05	.80	.72	.68	.48	.19	—
Blue slate	9.53	8.63	6.07	5.27	4.83	2.87	—	—
Significance	.95	.86	.60	.52	.48	.28	—	—
Dutox spray	6.66	5.76	3.20	2.40	1.96	—	—	—
Significance	.66	.57	.32	.24	.19	—	—	—
Diamond oil	4.70	3.80	1.24	.44	—	—	—	—
Significance	.47	.38	.12	—	—	—	—	—
Cyanide dust	4.26	3.36	.80	—	—	—	—	—
Significance	.42	.33	—	—	—	—	—	—
Bordeaux lead arsenate	3.46	2.56	—	—	—	—	—	—
Significance	.34	.25	—	—	—	—	—	—
Copper dust	.90	—	—	—	—	—	—	—
Significance	—	—	—	—	—	—	—	—

TABLE 8. REDUCTION IN AVERAGE NUMBER OF THRIPS PER PLANT OF TREATMENTS AT TOP OF TABLE, BELOW TREATMENTS AT SIDE OF TABLE, EXPERIMENT 4, 1931

Treatment	Nicotine dust	Naphtha flakes	Koloform	Wettable sulfur	Hydrated lime	Kolodust	Red slate	Cyanide	Blue slate	Copper dust	Dutox
Check.....	73.59	68.87	66.95	66.21	63.43	61.92	61.34	60.58	58.54	57.88	50.57
Significance...	6.39	5.99	5.82	5.75	5.52	5.38	5.33	5.27	5.09	5.03	4.39
Dutox dust....	23.02	18.25	16.38	15.64	12.86	11.35	10.77	10.01	7.97	7.31	—
Significance...	2.87	1.58	1.43	1.36	1.11	.99	.93	.87	.69	.62	—
Copper dust...	15.71	10.99	9.07	8.33	5.55	4.04	3.46	2.70	.66	—	—
Significance...	1.36	.95	.78	.72	.48	.35	.30	.23	—	—	—
Blue slate dust.	15.05	10.38	8.41	7.67	4.89	3.38	2.80	2.04	—	—	—
Significance...	1.31	.90	.73	.66	.42	.29	.24	.18	—	—	—
Cyanide dust..	13.01	7.29	6.37	5.63	2.85	1.34	.76	—	—	—	—
Significance...	1.13	.63	.55	.49	.24	.12	—	—	—	—	—
Red slate.....	12.25	7.53	5.61	4.87	2.09	.58	—	—	—	—	—
Significance...	1.06	.65	.48	.42	.18	—	—	—	—	—	—
Kolodust.....	11.67	7.95	5.03	4.29	1.51	—	—	—	—	—	—
Significance...	1.01	.69	.44	.37	.13	—	—	—	—	—	—
Hydrated lime.	10.16	5.44	3.52	2.78	—	—	—	—	—	—	—
Significance...	.88	.48	.31	.24	—	—	—	—	—	—	—
Wettable sulfur	7.38	2.66	.74	—	—	—	—	—	—	—	—
Significance...	.64	.23	—	—	—	—	—	—	—	—	—
Koloform.....	6.64	1.92	—	—	—	—	—	—	—	—	—
Significance...	.57	.16	—	—	—	—	—	—	—	—	—
Naphtha.....	4.72	—	—	—	—	—	—	—	—	—	—
Significance...	.41	—	—	—	—	—	—	—	—	—	—

PROTECTION OF CELERY FROM TARNISHED PLANT BUG INJURY

By L. L. HILL, *Ithaca, N. Y.*

ABSTRACT

The tarnished plant bug (*Lygus pratensis* Say) causes large losses to celery grown on muck land in Western New York. The injury results both from feeding and oviposition punctures in leaf stalks of the plants. Applications of finely ground sulphur as a dust and hydrated lime and finely ground sulphur as a spray successfully prevented both feeding and oviposition. Other materials gave fair results.

The celery crop of New York State valued at approximately two and one-fourth million dollars annually is subjected to substantial losses by the so called "black joint" or tarnished plant bug injury. The severity of the injury any season is apparently dependent upon the numbers of hibernating adults that emerge in the spring and perhaps also upon local weather conditions. In view of the fact that the loss to celery growers from ravages of this insect is a substantial one and that no satisfactory control measures have yet been reported a series of experiments were started in Wayne County, New York in June, 1930. These studies were primarily concerned with finding some repellents which would protect the celery from injuries resulting from feeding habits of this insect. During 1930 a large number of possible repellents were used on a small scale and the most promising of these selected for more extensive experiments in 1931. The present report is concerned only with results secured from 1931 experiments.

Tarnished plant bug injury, sting or black joint as the injury is commonly termed is caused by feeding punctures made on the leaf stem, usually in the region of the nodes although frequently, in cases of heavy infestation, along the entire stem of the tender leaves. Leaves thus punctured will turn dark as if infected with a bacterial rot. Whether the insect injects a bacterial organism into the plant at the time of feeding, whether the punctures themselves furnish entrances for bacteria or whether the injury is enzymatic is not known. Cultures made from badly injured stems have produced bacterial growth but a reinoculation of these organisms into healthy plants has failed to produce the injury.

During 1930 the tarnished plant bugs did not become numerous enough to produce noticeable injury to celery until early in September. The numbers of injured leaves increased rapidly from this time until celery was harvested—the increase being in proportion to the maturity of weeds along ditch banks, waste land and other sources of infestation. The injury here was from adult feeding. Little or no oviposition took

place in celery. The conditions were somewhat more complicated for the season of 1931. In the spring, according to our records, about ten times as many adults emerged from hibernation as did the preceding season; the females oviposited in many varieties of weeds during May.

TABLE 1. MATERIALS, DILUTIONS AND RATES OF APPLICATION IN TARNISHED PLANT BUG EXPERIMENTS

Material	Dilution per 50 gallons	Rate of application per acre
Experiments 1 and 2		
Hyrdated lime dust		150 pounds
Hydrated lime spray	25 pounds	200 gallons
Lime sulphur spray	12.5 pounds hydrated lime 12.5 pounds wettable sulphur	200 gallons
Sulphur spray	25 pounds	200 gallons
Sulphur dust		150 pounds
Slate dust		150 pounds
Slate spray	50 pounds	200 gallons
Experiments 3 and 4		
Hyrdated lime dust		150 pounds
Lime sulphur spray	25 pounds hydrated lime 25 pounds wettable sulphur	200 gallons
Hydrated lime spray	50 pounds	200 gallons
Sulphur spray	50 pounds	200 gallons
Sulphur dust		150 pounds
Slate dust		150 pounds
Slate spray	50 pounds	200 gallons
Experiment 5		
Hydrated lime dust		175 pounds
Hydrated lime spray	50 pounds	200 gallons
Lime sulphur dust	25 pounds hydrated lime 25 pounds dusting sulphur	175 pounds
Lime sulphur spray	25 pounds hydrated lime 25 pounds wettable sulphur	200 gallons
Lime slate dust	25 pounds hydrated lime 25 pounds slate dust	175 pounds
Lime slate spray	25 pounds hydrated lime 25 pounds slate dust	200 gallons
Sulphur dust		175 pounds
Sulphur spray	50 pounds	200 gallons
Slate dust		175 pounds
Slate spray	50 pounds	200 gallons
Experiment 6		
Hydrated lime spray	50 pounds	200 gallons
Slate dust spray	50 pounds	200 gallons
Lime sulphur spray	25 pounds hydrated lime 25 pounds wettable sulphur	
Lime nicotine spray	50 pounds hydrated lime 1 pint Blackleaf 40	200 gallons
Experiment 7		
Hydrated lime dust		100 pounds
Slate dust		100 pounds
Lime sulphur dust 50–50		100 pounds

The first brood matured in June and then large numbers flocked to celery fields where they oviposited in the celery. By the end of July from 5 to 30 nymphs could be found in practically any celery plant. Injury from nymphs is usually confined to the hearts. The infestation and injury in early celery was so heavy that very little of the crop passed inspection for U. S. No. 1 which permits only ten per cent sting. A few fields were entirely unfit for market.

FIELD EXPERIMENTS. In selecting experimental areas every effort was made to avoid fields where the infestation was likely to be uneven or where part of the experiment was exposed to waste land and part of it removed from such sources of infestation. In the first five experiments to be discussed, plats were arranged on the Latin Square Principle, so that each treatment was widely separated and replicated three times in the experiments to compensate for variation in infestation and for environmental factors. In the remaining two experiments plats were in parallel strips running the entire length of the field and were replicated.

In taking records of the number of injured leaves counts were made from the middle of each and all plats. These count areas were arranged in parallel strips across all plats so that the data secured might be statistically compared. The number of injured leaves for all plats of the same treatment in all experiments were summarized and compared statistically with the checks and with other treatments and the relative efficiency of various repellents has been presented as the decrease in number of injured leaves per plant. The error indicated in the significance with each reduction is the standard error, the significance being the mean difference divided by the standard error.

Materials, dilutions and rates of applications in tarnished plant bug experiments are to be found in Table 1, parts 1–4.

In experiment 1, Table 2, which was conducted in a field of early celery, Sulphur dust was most effective, showing a significant reduction of injured leaves per plant below slate spray, Sulphur spray and lime spray; Slate dust is significent only over slate spray. All materials in this experiment show a reduction below the check which is significant. Plats in this experiment were 1 square rod and each was replicated three times. Materials were applied with a rotary hand duster in case of dusts and with a hand sprayer in the case of liquids. Applications were made weekly, beginning July 15 and continuing until the celery was harvested on August 27, a total of 5 applications.

Experiment 2 is a replication of Experiment 1, conducted on another farm a few miles away. Sulphur dust was most effective, showing a significant reduction in numbers of injured leaves per plant below four

other materials listed in the table. Lime spray alone does not show a significant reduction below the check.

TABLE 2—EXPERIMENT 1. AVERAGE REDUCTION IN NUMBERS OF INJURED LEAVES PER PLANT, OF TREATMENTS AT TOP OF TABLE BELOW TREATMENTS AT THE SIDE, TOGETHER WITH THE SIGNIFICANCE OF THE REDUCTION

Treatment	Sulphur dust	Slate dust	Lime and sulphur spray	Lime dust	Lime spray	Sulphur spray	Slate spray
Check	3.86	3.86	3.08	2.98	2.74	2.60	2.28
Significance	7.39	6.82	5.90	5.70	5.24	4.97	4.36
Slate spray	1.58	1.28	.80	.70	.46	.32	—
Significance	3.02	2.45	1.53	1.34	.88	.61	—
Sulphur spray	1.26	.96	.48	.38	.14	—	—
Significance	2.41	1.83	.92	.72	.27	—	—
Lime spray	1.12	.82	.24	.24	—	—	—
Significance	2.14	1.57	.65	.46	—	—	—
Lime dust	.88	.58	.10	—	—	—	—
Significance	1.68	1.11	.19	—	—	—	—
Lime sulphur spray	.78	.48	—	—	—	—	—
Significance	1.49	.92	—	—	—	—	—
Slate dust	.30	—	—	—	—	—	—
Significance	.57	—	—	—	—	—	—

TABLE 3—EXPERIMENT 2. AVERAGE REDUCTION IN NUMBERS OF INJURED LEAVES PER PLANT, OF TREATMENTS AT TOP OF TABLE BELOW TREATMENTS AT SIDE AND THE SIGNIFICANCE OF EACH REDUCTION

Treatment	Sulphur dust	Slate spray	Lime and sulphur spray	Slate dust	Lime dust	Sulphur spray	Lime spray
Check	4.64	3.56	3.16	3.06	2.40	1.36	.24
Significance	6.17	4.74	4.20	4.07	3.19	2.21	.32
Lime spray	4.40	3.32	2.92	2.82	2.16	1.42	—
Significance	5.85	4.42	3.89	3.75	2.87	1.89	—
Sulphur spray	2.98	1.90	1.50	1.40	.74	—	—
Significance	3.96	2.53	2.00	1.86	.98	—	—
Lime dust	2.24	1.16	.76	.66	—	—	—
Significance	2.98	1.54	1.01	.88	—	—	—
Slate dust	1.58	.50	.10	—	—	—	—
Significance	2.10	.66	.13	—	—	—	—
Lime and sulphur spray	1.48	.40	—	—	—	—	—
Significance	1.97	.53	—	—	—	—	—
Slate spray	1.08	—	—	—	—	—	—
Significance	1.44	—	—	—	—	—	—

Experiments 3 and 4, (Tables 4 and 5), are duplicate experiments conducted on neighboring farms. The same materials were used and applied in the same manner as for the preceding experiments; dilutions were as indicated in Table 1, part 2. Applications were made weekly from August 14 until October 1, giving a total of six applications. Lime and sulphur spray and sulphur are most efficient in reducing the numbers of injured leaves per plant; the first giving a significant reduction over all other materials in experiment 3, while both give a significant reduction over the same materials in experiment 4. All materials listed in Table 5

gave a significant reduction below the check. In experiment 3 Lime spray, slate dust and slate spray did not give a reduction which can be considered significant.

TABLE 4—EXPERIMENT 3. AVERAGE REDUCTION IN NUMBERS OF INJURED LEAVES PER PLANT, OF TREATMENTS AT TOP OF TABLE BELOW TREATMENTS AT SIDE AND THE SIGNIFICANCE OF THE REDUCTION

Treatment	Lime and sulphur spray	Sulphur dust	Lime dust	Sulphur spray	Lime spray	Slate dust	Slate spray
Check	4.12	2.81	2.6	1.48	.93	.53	.48
Significance	6.61	4.51	4.17	2.37	1.50	.86	.80
Slate spray	3.64	2.33	2.12	1.00	.45	.05	—
Significance	5.88	3.74	3.40	.16	.7	.09	—
Slate dust	3.69	2.28	2.07	.95	.40	—	—
Significance	3.75	3.66	3.31	1.52	.64	—	—
Lime spray	3.19	1.88	1.67	.45	—	—	—
Significance	5.11	3.01	2.67	—	—	—	—
Sulphur spray	2.64	1.33	1.12	—	—	—	—
Significance	4.23	2.14	1.80	—	—	—	—
Lime dust	1.52	.21	—	—	—	—	—
Significance	2.44	.34	—	—	—	—	—
Sulphur dust	1.31	—	—	—	—	—	—
Significance	2.10	—	—	—	—	—	—

TABLE 5—EXPERIMENT 4. AVERAGE REDUCTION IN NUMBERS OF INJURED LEAVES PER PLANT, OF TREATMENTS AT TOP OF TABLE BELOW TREATMENTS AT SIDE AND THE SIGNIFICANCE OF THE REDUCTION

Treatment	Sulphur dust	Lime and sulphur spray	Sulphur spray	Lime spray	Slate dust	Lime dust	Slate spray
Check	4.82	4.76	3.44	3.16	2.65	2.56	2.31
Significance	8.18	8.07	5.83	5.36	4.50	4.34	3.91
Slate spray	2.51	2.45	1.13	.85	.34	.25	—
Significance	4.27	4.16	1.92	1.45	.57	.43	—
Lime dust	2.26	2.20	.88	.60	.09	—	—
Significance	3.84	3.73	1.49	1.02	.16	—	—
Slate dust	2.17	2.11	.79	.51	—	—	—
Significance	3.68	3.57	1.33	.86	—	—	—
Lime spray	1.66	1.60	.28	—	—	—	—
Significance	2.83	2.71	.47	—	—	—	—
Sulphur spray	1.38	1.32	—	—	—	—	—
Significance	2.35	2.23	—	—	—	—	—
Lime and sulphur spray	.06	—	—	—	—	—	—
Significance	.11	—	—	—	—	—	—

In experiment 5, Table 6 the results substantiate the findings of the two preceding experiments in that lime and sulphur spray and sulphur dust are most effective in reducing the injury. Lime and sulphur dust was the next best treatment. Here again the reduction of injured leaves per plant below the check is significant for all materials in the experiment.

Plats in experiment 6, (Table 7) were one acre each in size and ran in parallel strips across a four and one-half acre block of celery. Materials

TABLE 6. EXPERIMENT 5. AVERAGE REDUCTION IN NUMBERS OF INJURED LEAVES PER PLANT, OF TREATMENTS AT TOP OF TABLE BELOW TREATMENTS AT SIDE AND THE SIGNIFICANCE OF THE REDUCTION

Treatment	Lime and sulphur spray	Sulphur dust	Lime and sulphur dust	Lime and slate spray	Sulphur spray	Slate spray	Lime and slate dust	Lime dust	Slate dust	Lime spray
Check	3.11	2.97	2.66	2.42	2.25	2.14	2.05	1.57	1.42	1.16
Significance	5.38	5.14	4.59	4.20	3.89	3.70	3.55	2.71	2.47	2.00
Lime spray	1.95	1.81	1.50	1.26	1.09	.98	.89	.41	.26	—
Significance	3.37	3.13	2.59	2.18	1.88	1.69	1.54	.71	.45	—
Slate dust	1.69	1.55	1.24	1.00	.83	.72	.63	.15	—	—
Significance	2.92	2.68	2.14	1.73	1.43	1.24	1.09	.26		—
Lime dust	1.54	1.40	1.09	.85	.68	.57	.48	—	—	—
Significance	2.66	2.42	1.88	1.47	1.17	.98	.83	—	—	—
Lime and slate dust	1.06	.92	.61	.37	.20	.09	—	—	—	—
Significance	1.83	1.59	1.05	.63	.34	.15	—	—	—	—
Slate spray	.97	.83	.52	.28	.11	—	—	—	—	—
Significance	1.63	1.43	.90	.48	.19	—	—	—	—	—
Sulphur spray	.86	.72	.41	.17	—	—	—	—	—	—
Significance	1.48	1.24	.71	.29	—	—	—	—	—	—
Lime and slate spray	.69	.55	.24	—	—	—	—	—	—	—
Significance	1.19	.95	.41	—	—	—	—	—	—	—
Lime and sulphur dust	.45	.31	—	—	—	—	—	—	—	—
Significance	.77	.53	—	—	—	—	—	—	—	—
Sulphur dust	.14	—	—	—	—	—	—	—	—	—
Significance	.24	—	—	—	—	—	—	—	—	—

were applied with a power sprayer, spraying eight rows at a time, three nozzles to the row and with four hundred pounds pressure. In the results of this experiment we are comparing the efficiency between different sprays only.

TABLE 7—EXPERIMENT 6. AVERAGE REDUCTION IN NUMBERS OF INJURED LEAVES PER 5 PLANTS OF TREATMENT AT TOP OF TABLE BELOW TREATMENT AT SIDE AND THE SIGNIFICANCE OF THE REDUCTION

Treatment	Lime and sulphur spray	Slate spray	Lime spray
Lime nicotine spray	16.10	6.38	.45
Significance	5.65	2.24	.16
Lime spray	15.65	5.93	—
Significance	5.49	2.08	—
Slate spray	9.72	—	—
Significance	3.41	—	—

TABLE 8—EXPERIMENT 7. AVERAGE REDUCTION IN NUMBERS OF INJURED LEAVES PER PLANT, OF TREATMENTS AT TOP OF TABLE BELOW TREATMENTS AT SIDE AND THE SIGNIFICANCE OF THE REDUCTION

Treatment	Lime and sulphur dust	Slate dust	Lime dust
Check	4.25	1.41	1.37
Significance	6.41	2.13	2.07
Lime dust	2.88	.04	—
Significance	4.34	.05	—
Slate dust	2.84	—	—
Significance	4.28	—	—

TABLE 9—AMOUNTS OF MATERIALS USED PER ACRE AND THE HYDROGEN-ION CONCENTRATION OF SOIL FROM THE PLATS OF EXPERIMENTS 3 AND 4

	Material used and amount per acre							
	Slate dust 900 lbs. *pH*	Lime spray 1200 lbs. *pH*	Sulphur dust 900 lbs. *pH*	Slate spray 1200 lbs. *pH*	Lime sulphur 1200 lbs. *pH*	Lime dust 900 lbs. *pH*	Sulphur spray 1200 lbs. *pH*	Check *pH*
				Experiment 4				
Series A	6.04	5.95	4.99	5.55	5.50	5.75	5.38	5.84
Series B	5.70	6.12	4.80	5.57	5.40	5.72	5.38	5.84
Series C	5.90	6.15	5.10	5.70	5.32	5.90	5.30	5.78
				Experiment 3				
Series A	5.24	5.78	4.30	5.04	4.79	5.25	4.30	4.82
Series B	5.37	5.51	4.00	5.06	4.94	5.48	4.44	5.25
Series C	5.29	5.19	4.47	5.20	4.89	5.35	4.50	5.02

A hundred plants were counted in three established count areas, making a total of 300 plants for each treatment. Count areas ran parallel across all treatments. Lime and sulphur spray gave a reduction below all other materials which is significant in the experiment. Slate spray is significant over all treatments except lime sulphur spray while lime spray and lime nicotine spray gave no significant reduction.

The plats in Experiment 7, (Table 8) were one-half acre each in size and were arranged in parallel strips across the field. Materials were applied by means of a power duster. Lime and sulphur dust gave a reduction of injured leaves per plant which is significant over all other materials in the experiment, slate dust and lime dust gave reductions significant only over the check.

Table 9 shows the amounts of different materials used per acre in experiments 3 and 4 and the effect of the different materials upon the hydrogen-iron concentration of the soil.

SUMMARY

The tarnished plant bug (*Lygus pratensis* Say) causes large losses to celery grown on muck land in Western New York. The injury results both from feeding and oviposition punctures in leaf stalks of the plants. The real cause of the blackening of celery joints following plant bug feeding is not apparent. Applications of finely ground sulphur as a dust and hydrated lime and finely ground sulphur as a spray successfully prevented both feeding and oviposition.

Slate dust and hydrated lime were more effective as dusts than as liquid sprays. Preparations containing nicotine did not prevent injury. Several procedures are available to growers by means of which tarnished plant bug injury to celery may be prevented. Further work however is essential because the large amounts of sulphur and lime which must be applied to celery plants may have some undesirable effects on soils over a period of years.

TIME OF LEAVING THE FRUIT BY ORIENTAL FRUIT MOTH LARVAE

By L. R. CAGLE, *Virginia Agricultural Experiment Station*

ABSTRACT

An apparatus was devised for obtaining continuous data on the time of day at which larvae of *Laspeyresia molesta* left the fruit. Practically all larvae left the fruit at night. They were obtained in largest numbers after midnight.

Some observations were made in 1930 on the time of day at which oriental fruit moth larvae left the fruit. Infested apples were examined at four-hour intervals from 8 a. m. July 19 to 8 a. m. the following day. Larvae were obtained as follows: noon, 1 larva; 4 p. m., 1 larva; 8 p. m., 0 larva; midnight, 6 larvae; 4 a. m., 58 larvae; and 8 a. m., 25 larvae. This record was supported by other observations.

An apparatus (Fig. 37) was devised this season for obtaining continuous data on the above point. A wheel 37 inches in diameter was constructed of light material. The framework, consisting of 12 spokes

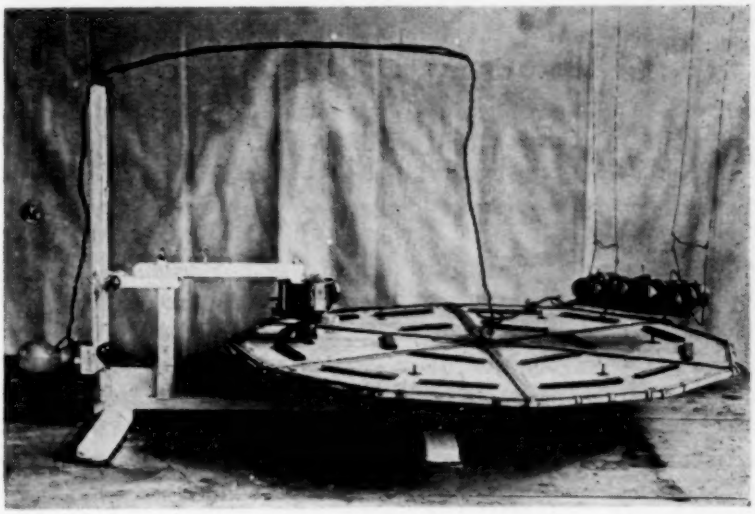

FIG. 37.—Apparatus devised for obtaining continuous data on time of leaving fruit by oriental fruit moth larvae.

and the rim, was made of 1/3 by ½ inch strips of basswood, and the wheel was covered with cloth. The wheel was fastened to the face of a 14½ inch wooden pulley. The spindle on which the pulley turned operated in a vertical metal socket fitted in a wooden base. The lower end of the spindle rested on the curved surface of a steel ball at the bottom of the socket. The wheel turned with very little friction and with practically no play. The turning of the wheel was accomplished by a one-ounce weight attached to a cord wound around the pulley and passed horizontally to a small pulley beyond the circumference of the wheel and then over another small pulley fastened at the ceiling of the insectary.

The wheel was divided into six equal parts, or sectors, the borders of which corresponded with the rim and alternate spokes. A barrier to prevent the escape of larvae was constructed around each sector in the following way: Strips of ½ inch aluminum ribbon were fastened firmly to the rim, to alternate spokes, and around the center so as to form a connected border of the metal around the six sectors. A layer of rubber ¼ inch wide was then fastened by means of shellac over the metal

ribbon so as to leave exposed a margin of the metal 1/8 inch wide. A second layer of the aluminum ribbon ¼ inch wide was then fastened by means of shellac and clamps, wherever possible, over the rubber, which served as insulation between the two layers of the metal. All connections were soldered by means of aluminum solder. The two layers of the metal serving as electrodes were connected directly to the light wires. The connections were made at the center as shown in the figure. A fuse or a light bulb was installed in the circuit as a safeguard against any short which might occur in the apparatus. Larvae upon trying to cross the barrier came in contact with the two electrodes and were killed or driven back. Strips of corrugated paper were supplied for cocooning quarters.

Apples containing oriental fruit moth larvae were placed above the wheel so that all larvae dropping at a specified time would fall within the same sector. The fruit was placed on a piece of window glass fastened in the position shown in the figure. Larvae frequently crawled over the edge of the glass and back several times before dropping to the wheel. Some were noted to drop on a thread of silk almost to the wheel and then wind themselves back to the glass. Satisfactory results were finally obtained by constructing electrodes of aluminum ribbon around the upper and lower edges of the glass and connecting these to the light wires. Larvae in crawling over the edges came in contact with the two electrodes and frequently fell instantly. Also larvae which succeeded in getting to the under surface of the glass had less chance of getting back to the upper surface again.

The wheel was shifted from one space to the next at 2 hour intervals. The timing of the shifting was accomplished by means of an ordinary alarm clock arranged as shown in the figure. A metal cup 1½ inches in diameter and 1 1/8 inches deep was soldered to a brass tube. The end of the tube was placed loosely over the hour hand shaft, a lug on the side of the shaft fitting in a notch in the tube. The mechanism was supported by a piece of wood clamped across the face of the clock. Six slots 5/8 inch deep and 3/16 inch wide were cut in the side of the cup so that their front edges were 60 degrees apart. Pins ½ inch high screwed in the spoke in the middle of each sector of the wheel served as stops for the wheel. As the wheel turned each pin passed through two slots one in the back and one in the front of the cup. The slots were so arranged that a pin could not pass through both at the same time. When a pin was released in front, therefore, the back wall of the cup served as a stop for the next pin.

In developing the apparatus it was observed that larvae were able to

cross a band of tree tanglefoot 1½ inches wide with ease, either when used alone or when diluted with kerosene.

TABLE 1. NUMBER OF LARVAE CAUGHT DURING EACH TWO-HOUR PERIOD BEGINNING AT 8 A.M.

	Number of larvae taken during the two-hour periods												
	A.M.				P.M.					A.M.			
	8–10	10–12	12–2	2–4	4–6	6–8	8–10	10–12	12–2	2–4	4–6	6–8	Total
June	0	1	0	0	2	3	10	7	12	7	17	0	59
July	0	0	5	1	4	0	7	27	45	69	176	14	348
Aug.	0	0	0	0	0	0	3	9	16	12	22	3	65
Sept.	1	1	0	0	0	0	5	15	27	17	19	2	87
Oct.	1	0	0	0	0	0	4	8	1	1	1	2	18
Total	2	2	5	1	6	3	29	66	101	106	235	21	577

Larvae were removed at 8 a. m., and 8 p. m., each day. The experiment was begun on June 24 and records were obtained for 7 days in June, 17 days in July, 12 days in August, 18 days in September, and 3 days in October. The results are summarized in Table 1. A total of 577 larvae were caught during the 57 days that the data were obtained. Of this number, only 3.3 per cent were obtained during the daylight period from 8 a. m., to 8 p. m. The maximum numbers were taken between 4 and 6 a. m., during June, July and August, between midnight and 2 a. m., in September, and between 10 p. m., and midnight in October. Due to the small number of larvae collected in late season, further studies will be necessary to substantiate the data which indicate that larvae at that time tend to emerge at an earlier hour of the night.

FURTHER STUDIES OF THE PHYSICAL ECOLOGY OF THE ALFALFA WEEVIL, *HYPERA POSTICUS* (GYLLENHAL)[1]

By HARVEY L. SWEETMAN, *Massachusetts State College, Amherst, Mass.*

ABSTRACT

The responses of all stages of the pest to the various physical factors under field conditions are given in the paper. The insects were maintained in cages in three positions; near the ground, at the tops of the plants, and three feet above the surface of the soil.

Climate is well recognized by entomologists as being an important means of controlling the distribution and abundance of insects. This is true of the alfalfa weevil as well as many other insects. A project was started in Wyoming in 1927 to determine the probabilities of this pest

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becoming established in the Mississippi Valley States. One report dealing with the physical environment and habits of the weevil in an alfalfa field has been published (Sweetman, 1929). This paper con-

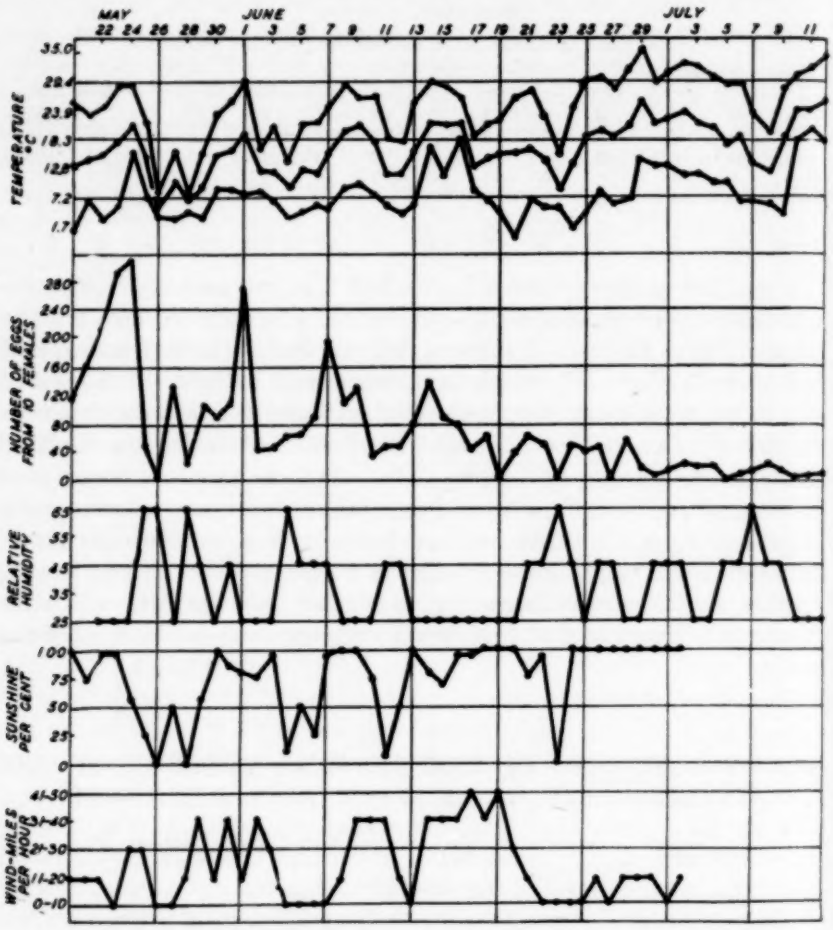

FIG. 38.—The daily oviposition rates of ten beetles and the physical environment at three and one-half feet above the ground. Total number of eggs 3754; mean maximum temperature 25.4°; mean temperature 16.3°; mean minimum temperature 7.5°.

sidering the effects of temperature and moisture on the pest under field conditions is the second.

These data were taken in connection with life history and developmental studies of the insect in its natural environment. The insects

used were exposed to as nearly normal environmental conditions as possible under the circumstances. This afforded an opportunity for close comparisons of the results of field and laboratory studies (In press). Parks (1914) has published some information on the effects of temperature on oviposition of the alfalfa weevil, but did not make temperature measurements in the vicinity of the cages.

PHYSICAL DATA. Temperature and relative humidity records were secured at three different levels. All stages of the alfalfa weevil were maintained at these positions. The lower level was two inches above the ground, the second at the tops of the plants and therefore varied in the distance above the ground, while the top level was three and one-half feet above the ground. The latter position corresponds to the height at which most United States Weather Bureau records are taken. The temperature was measured with thermographs and maximum and minimum thermometers. The relative humidity was secured with hygrographs and a sling psychrometer. Precipitation was recorded with the aid of a standard three-inch rain gauge. Wind velocities for this season were estimated by observation and use of the Beaufort scale. The hours of sunshine were determined by hourly observations.

Temperature. The temperature record for the lower level was slightly below the actual field conditions since the shade necessary for the recording instruments prevented the soil from becoming heated normally by the direct sunshine. The shelter consisted of a top shade during midday. An east and west shade was supplied in the morning and evening as needed. This permitted the soil and plants under the shelter to be exposed to the direct sunshine for a part of each day. Constant attention was necessary to protect the recording instruments from the direct sunshine.

The temperatures at the tops of the plants and at three and one-half feet above the ground were very similar. The mean temperature at the upper position from May 20 to July 12 was 16.3°C. and the mean at the tops of the plants from May 26 to July 11 was 16.4° (Figs. 38, 39). The mean temperature at the two-inch level was 15.2° (Fig. 40). This corroborates the conclusions reached previously, that the daily mean temperatures at these positions are very similar (Sweetman, 1929) and re-emphasizes the value that can be attached to the United States Weather Bureau records taken three and one-half to four and one-half feet above the soil for approximating the temperature conditions in nearby alfalfa fields.

Relative Humidity. The mean humidity, 54.4 per cent, at the lower level was much greater than at three and one-half feet above the soil,

and was in excess of that, 46.3 per cent, at the tops of the plants (Figs. 39, 40). The humidity at the upper position was taken with a sling psychrometer at intervals during the day so that the curve is not directly com-

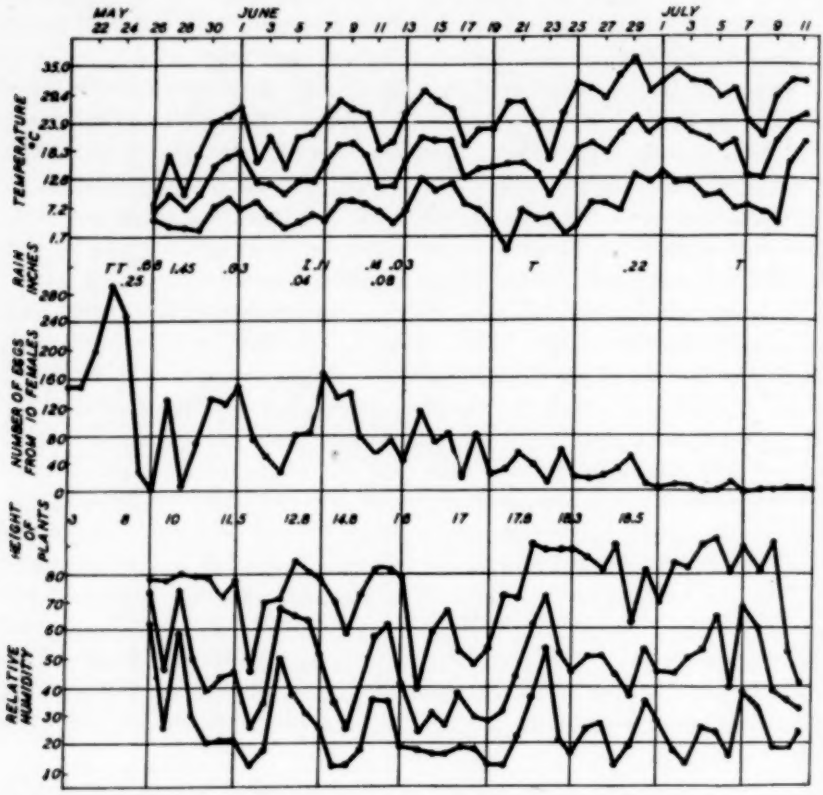

FIG. 39.—The daily oviposition rates of ten beetles and the physical environment at the tops of the alfalfa plants. Total number of eggs 3447; mean maximum temperature 24.9°; mean temperature 16.4°; mean minimum temperature 7.8°; mean maximum relative humidity 74.2 per cent; mean relative humidity 46.3 per cent; mean minimum relative humidity 25.4 per cent; T-trace; I-irrigation.

parable to the records at the other levels, but the difference in the daily minimum humidities is roughly shown (Fig. 38). This curve shows the minimum conditions that were reached during a few hours each day. Humidities of 25 per cent or less were plotted at the 25 per cent line, from 26 to 50 per cent at the 45 per cent line, and from 51 to 75 per cent at the 65 per cent line. The daily minimum humidity at this level never exceeded 75 per cent during the daylight hours. The differences

in humidity at the various positions is in accord with previous records (Sweetman, 1929), and re-emphasizes the caution that must be exercised in using United States Weather Bureau relative humidity records in estimating actual field conditions among the alfalfa plants.

Precipitation and Irrigation. The rainfall was plentiful in the latter part of May, but was very low during June and early July. During the period of the experiments, 3.03 inches of precipitation occurred, but 2.38 inches of this fell in May (Fig. 39). One application of irrigation water was made on June 6. This shows that conditions were rather dry during the time the first crop of hay was developing and probably accounts for the limited growth of the plants after June 15 (Fig. 39).

Wind Velocity and Sunshine. The maximum wind velocity that was attained for a few hours each day is plotted in Figure 38. A rather high average is indicated. The hours of sunshine were very great, 73 per cent of the days having 70 per cent or more of sunshine (Fig. 38). The wind velocity, sunshine, and low rainfall tended to produce very dry conditions, which were not offset by irrigation.

Biological Data. All stages of the alfalfa weevil were held at the three positions in the immediate proximity of the recording instruments. The adults and larvae were kept in glass tubing cages about two inches in diameter and five inches in length. The ends of the cages were covered with cheese cloth. The food was maintained in a fresh condition by inserting the stems through corks into vials of water. The cages usually were kept parallel with the wind so that air currents would pass directly through them. Only a small amount of food was placed in the cages at one time so as to avoid excessive moisture from transpiration and to permit ample space for air movement through the cages. Shaking of the leaves in the cages by the wind showed that air currents were passing through the cages. The eggs were placed in vials covered with cheese cloth.

Adult Stage. Records of oviposition of ten adults at each position were taken from May 20 to July 12. The beetles were collected in the field and pairs isolated. Apparently all of the females were laying when caught as eggs were found in the cages the first or second day after collection.

The effects of temperature were very noticeable at all levels. The heaviest oviposition occurred in May, but two cold days, May 26 and 28, reduced the number of eggs laid to practically zero (Figs. 38, 39, 40). Oviposition was resumed immediately with the return of warm weather. The minimum effective temperature for oviposition of the alfalfa weevil is not definitely known. When the oviposition rates are compared with

the results from controlled environments (In press) the daily maximum temperatures during the early part of the season when many eggs were produced are shown to be near the optimum for oviposition. Practically all of the beetles had discontinued oviposition by July 12, but a considerable number of the eggs were laid at the lower level during the last week (Tables 1, 2, 3). The lowest number of eggs, 3155, was produced at the two-inch position where the mean temperature was more than a degree lower than at the other positions.

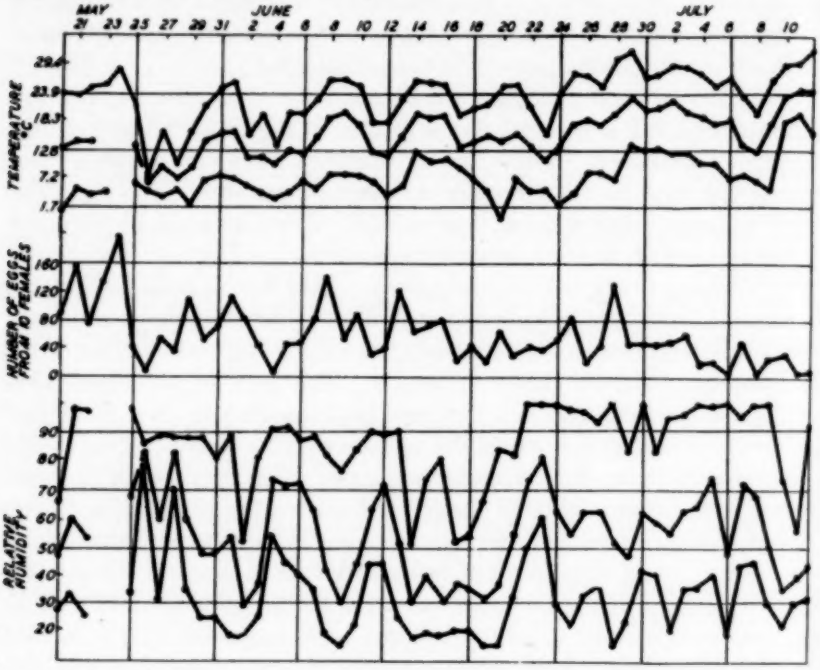

FIG. 40.—The daily oviposition rates of ten beetles and the physical environment among the plants two inches above the soil. Total number of eggs 3155; mean maximum temperature 23.2°; mean temperature 15.2°; mean minimum temperature 6.4°; mean maximum relative humidity 85.9 per cent; mean relative humidity 54.4 per cent; mean maximum relative humidity 30.9 per cent.

The effects of relative humidity on the adults could not be ascertained under field conditions. The greatest oviposition occurred at the upper level where the relative humidity was lowest and the smallest number of eggs were laid at the lower level where the humidity was highest (Figs. 38, 39, 40). This probably was a response to temperature rather than humidity as the heaviest oviposition was associated with the highest humidity in the controlled environments (In press).

TABLE 1. THE NUMBER OF EGGS LAID BY TEN BEETLES PLACED IN CAGES THREE AND ONE-HALF FEET ABOVE THE GROUND

Beetle number	May	June					July		Total number
	20–25	26–1	2–8	9–15	16–22	23–29	30–6	7–12	
1	96	59	61	81	29	37	0	0	363
2	89	49	51	35	25	14	0	0	263
3	166	103	89	59	37	0	0	0	454
4	146	108	62	97	28	0	0	0	441
5	92	59	72	77	80	66	68	34	548
6	61	76	39	53	17	0	0	0	246
7	78	50	53	52	41	37	0	0	311
8	183	85	61	1	0	0	0	0	330
9	85	70	68	79	86	70	12	28	498
10	130	85	42	43	0	0	0	0	300
Totals....	1126	744	598	577	343	224	80	62	3754

TABLE 2. THE NUMBER OF EGGS LAID BY TEN BEETLES PLACED IN CAGES AT THE TOPS OF THE ALFALFA PLANTS

Beetle number	May	June					July		Total number
	20–25	26–1	2–8	9–15	16–22	23–29	30–6	7–12	
1	123	71	59	16	0	0	0	0	269
2	110	52	72	90	32	8	0	0	364
3	117	63	89	68	14	6	0	0	357
4	55	35	28	19	20	39	36	6	238
5	119	73	71	43	6	2	0	0	314
6	84	77	59	83	39	15	0	0	357
7	126	77	60	20	47	39	4	0	373
8	118	83	102	116	94	35	0	0	548
9	94	19	6	4	0	0	0	0	123
10	119	59	69	103	81	73	0	0	504
Totals....	1065	609	615	562	333	217	40	6	3447

TABLE 3. THE NUMBER OF EGGS LAID BY TEN BEETLES PLACED IN CAGES TWO INCHES ABOVE THE GROUND

Beetle number	May	June					July		Total number
	20–25	26–1	2–8	9–15	16–22	23–29	30–6	7–12	
1	133	84	88	31	7	0	0	0	343
2	60	42	39	3	0	0	0	0	144
3	60	35	74	67	6	90	33	0	365
4	88	44	66	92	58	78	67	39	532
5	36	24	14	35	4	0	0	0	113
6	49	0	11	17	46	60	5	0	188
7	55	66	54	57	67	78	79	0	456
8	64	45	34	59	53	50	35	50	390
9	74	64	54	82	63	52	16	26	431
10	77	45	28	29	11	2	1	0	193
Totals....	696	449	462	472	315	410	236	115	3155

Observations were made of the night activities of the beetles during the warm nights in the middle of June. It was found that movement, feeding, and mating continued as during daylight hours when the temperature was high enough. Night oviposition was not observed. The humidity among the alfalfa plants would be high at night. In Utah, Reeves (1927) found that activities were greatest at night during extremely hot weather.

Egg Stage. The eggs exposed at the three and one-half foot level required an average incubation period of 19 days, only 45.6 per cent of the eggs hatching (Table 4). Thirty-one days were necessary for incubation during the cooler part of the season, but the time necessary was

TABLE 4. THE INCUBATION PERIODS OF EGGS PLACED THREE AND ONE-HALF FEET ABOVE THE GROUND

Date started	No. of eggs	Per cent hatched	Days to hatch Range	Mean
5–21–29	88	13.6	22–25	22.8
22	161	28.0	21–23	21.4
23	134	62.7	20–25	21.9
24	118	35.6	20–31	26.3
25	125	43.2	22–29	27.1
26	46	19.6	22–29	25.7
28	112	35.7	20–26	22.6
29	20	30.0	22–25	23.5
30	74	12.2	22–24	23.3
31	52	59.6	20–23	22.5
6–1–29	100	70.0	20–27	21.5
2	112	70.5	20–24	20.3
3	42	45.2	17–25	19.9
4	37	59.5	18–19	18.8
5	59	33.9	16–21	19.3
6	60	50.0	16–22	18.1
7	81	59.3	14–19	17.0
8	114	63.2	14–20	17.3
9	99	49.5	16–22	17.5
10	94	70.2	16–21	17.6
12	51	54.9	16–18	17.3
13	43	62.8	14–19	15.6
15	110	50.0	14–20	15.9
18	43	41.9	14–16	15.4
21	36	58.3	12–14	13.1
25	50	42.0	9–11	10.3
26	36	41.6	9–12	9.7
27	51	13.7	9–13	11.1
	2,148	45.6	9–31	19.0

reduced to nine days during the warmer weather in July (Fig. 38). The poorest hatches occurred from eggs laid in May when the weather was cool and wet. Later a minimum temperature of — 0.8°C. on June 20 when the weather was dry apparently did not injure the developing embryos, but the maximum and mean temperatures were high on that day. The minimum effective temperature for development during the incubation of the eggs is near 10° (In press). The daily mean temperature was 10°, or below, about eight per cent of the time and the daily minimum temperature was below 10° most of the season, thus accounting for the long incubation periods in the early part of the season. No apparent reduction in the percentage of exposed eggs that hatched was found when the humidity was lowest during the middle of June (Fig. 38).

Since the hatching was generally poor at this level it is probable that low humidities of 50 per cent or less for a few hours during the day were sufficient to kill many of the embryos. The daily minimum humidity was below 50 per cent for a few hours on 46 days and above that for six

TABLE 5. THE INCUBATION PERIODS OF EGGS PLACED AT THE TOPS OF THE PLANTS

Date started	No. of eggs	Per cent hatched	Days to hatch Range	Mean
5-21-29	153	19.0	22–27	23.8
22	102	79.4	21–31	29.8
23	114	31.6	23–31	24.6
24	130	17.7	24–32	27.2
25	102	2.9	25–29	27.0
26	33	3.0	26	26.0
28	108	24.1	23–26	24.9
29	8	0.0	———	———
30	70	35.7	18–24	22.6
31	112	58.9	20–23	22.0
6- 1-29	110	62.7	19–25	21.4
2	100	61.0	19–25	21.4
3	107	15.9	20–24	21.5
4	50	58.0	18–22	19.1
5	26	61.5	17–23	18.4
8	150	73.3	14–20	17.2
9	118	74.6	16–22	17.1
10	123	58.5	16–21	17.8
12	44	47.7	16–18	17.2
13	68	83.8	15–17	16.2
15	94	42.5	15–16	15.3
18	16	6.2	14	14.0
20	22	77.3	13–15	13.2
25	56	26.8	10–15	11.5
26	22	54.5	10–12	10.8
27	11	27.3	11–13	11.7
	2,049	42.5	10–31	19.8

days only. The normal moisture conditions in the green stems where the eggs are usually laid is probably high so that the eggs ordinarily would not be exposed to such low humidities.

The percentage of exposed eggs hatching at the tops of the plants was 42.5 (Table 5). This is three per cent lower than the hatch at the upper level, but some unexplained condition during the first week of the experiment produced an unusually low hatch. A number of eggs, 22 per cent, during this period turned milky white in color. A similar appearance of eggs at the other levels was rare as only one at the upper evel and four at the lower were found. This condition did not develop after May 29 and may have been caused by the cold, wet weather at this time (Fig. 39). A colder night on June 20 during dry weather when the minimum temperature was — 2°C. did not produce a similar effect and apparently did not reduce hatching. The time necessary for hatching

was closely related to the temperature. The daily mean temperature was below the minimum effective temperature, 10°, about 13 per cent of the time, while the daily minimum temperature was below the minimum effective temperature about 80 per cent of the time. No direct correlation of percentage of hatch and temperature was evident, but the mean humidity was low, which probably accounts for the poor hatch at this position.

TABLE 6. THE INCUBATION PERIODS OF EGGS PLACED NEAR THE GROUND AMONG THE PLANTS

Date started	No. of eggs	Per cent hatched	Days to hatch Range	Mean
5–21–29	61	65.6	25–32	27.5
22	123	70.7	25–32	28.1
23	56	60.7	25–32	28.3
24	60	85.0	19–30	27.0
25	73	53.4	26–29	27.2
26	50	84.0	25–33	27.9
28	44	52.3	23–31	26.8
29	35	77.1	19–25	22.4
30	85	51.8	22–28	23.4
31	40	77.5	21–27	22.6
6– 1–29	27	70.4	20–22	21.2
2	90	88.9	20–27	22.9
3	32	75.0	20–23	22.8
5	8	87.5	19–21	20.3
6	35	68.6	18–23	20.0
7	41	95.1	16–22	19.3
8	68	83.8	18–23	20.0
9	132	76.5	19–21	20.1
10	36	86.1	19–20	19.5
13	31	61.3	16–18	17.0
15	59	66.1	15–18	15.9
18	28	75.0	15–18	16.6
20	22	68.2	13–15	14.2
25	51	68.6	10–16	13.3
26	80	73.7	11–16	13.8
27	21	71.4	11–15	13.3
	1,388	72.8	10–32	21.2

A high percentage of the exposed eggs hatched at the two-inch level, but about two days longer were necessary for development than at the other positions (Table 6). The time required is associated with the lower temperature found at this level (Fig. 40). No evident injury developed from the cold night on June 20 when the minimum temperature was — 0.3°C. The daily minimum temperature was less than the minimum effective temperature about 81 per cent of the season so that development was arrested for at least a part of most of the days. The high percentage of eggs hatching is apparently associated with the high humidity found at this position, which indicates that the poor hatching

of the eggs at the upper positions was produced by the dry environments.

Larval Stage. Complete development of a few of the larvae was not secured because of lack of time due to the delay in hatching larvae at the start of the season. The larvae were placed on the growing tips of stems, kept fresh in water, shortly after hatching.

The records for larval development at the different positions are shown in Tables 7, 8, and 9. The larvae completed the feeding periods at all levels, requiring 22.9 days at the upper position, 24.8 days at the tops of the plants, and 27.7 days at the lower position. A few larvae transformed and emerged at the two upper levels in 34.8 and 37.0 days. This makes almost two months that were necessary for development of the immature stages. The length of the developmental periods was closely associated with the temperature. The minimum effective temperature for development during the feeding period is about 10°C. (In press), but during the pupation period is about 13°. The records show that the daily mean temperature was below 10° about 10 per cent of the time and below 13° about 32 per cent of the time (Figs. 38, 39, 40). The daily maximum temperature was near the optimum for larval development and transformation. No definite effects of humidity were observed.

An excellent opportunity developed on June 20 to determine the effect of freezing temperatures on the larvae. The minimum temperature at the tops of the plants was about — 2°C. and remained below freezing for about two hours, killing the upper inch or two of many of the plants. A large number of frozen portions of the stems were removed and examined before the larvae became active in the morning. Many larvae were found and all of them appeared to be normal in every way and resumed feeding when placed on fresh plants. The minimum temperatures preceding this date had been several degrees above freezing. Reeves *et al* (1920) made the same observation in Utah.

Observations of the larvae during the warmest nights showed that they were secluded and inactive during darkness under the conditions observed. As daylight appeared they became active and exposed on the outer parts of the plants if the temperature was favorable.

Conclusions

The conclusions regarding the physical conditions in alfalfa fields agree with those reached in previous seasons (Sweetman, 1929).

Daylight temperatures were very favorable for oviposition while night temperatures generally were too low.

TABLE 7. LARVAL DEVELOPMENT AT A POSITION THREE AND ONE-HALF FEET ABOVE THE GROUND

Date started	Days feeding	Days as prepupa	Days as pupa	Days to emerge	Total days
6- 4-29	25	1	7	3	36
6	25	2	7	1	35
7	22	2	8	2	34
7	23	2	9	2	36
7	25	2[1]	–	–	—
9	22	2	8	2	34
9	22	4	6	2	34
11	24	3	7[1]	–	—
11	22	4[1]	–	–	—
12	22	3	6[1]	–	—
12	22	3[1]	–	–	—
12	22	3[1]	–	–	—
12	22	3[1]	–	–	—
12	22	3[1]	–	–	—
12	24[1]	–	–	–	—
Average	22.9	2.6	7.3	2.0	34.8

[1]Experiment closed before development was completed.

TABLE 8. LARVAL DEVELOPMENT AT A POSITION ON A LEVEL WITH THE TOPS OF THE PLANTS

Date started	Days feeding	Days as prepupa	Days as pupa	Days to emerge	Total days
6- 4-29	26	3	8	2	39
4	27	3	8	1	39
7	24	2	8	2	36
7	24	3	8	1	36
7	26	2	7	1	36
7	25	3	7	1	36
7	27	died	–	–	—
7	30	4[1]	–	–	—
10	23	4[1]	–	–	—
12	22	3[1]	–	–	—
12	23	4[1]	–	–	—
12	23	5[1]	–	–	—
12	23	5[1]	–	–	—
Averages	24.8	3.4	7.7	1.3	37.0

[1]Experiment closed before experiment was completed.

TABLE 9. LARVAL DEVELOPMENT IN A POSITION NEAR THE SURFACE OF THE GROUND

Date started	Days feeding	Days as prepupa	Date started	Days feeding	Days as prepupa
6- 7-29	28	5	6-12-29	25	5
7	29	5	12	25	5
7	29	6	12	25	5
7	30	5	12	26	4
7	32	3	12	30	–
8	27	5	12	25	5
10	28	4	12	25	5
10	29	3	12	28	3
10	29	4	12	28	3
Averages				27.7	4.4

The hatching of the eggs in the natural environment probably is controlled largely by temperature since the eggs are laid within the stems of the plants. The percentage of the eggs hatching, if exposed, is greatly reduced when the mean relative humidity is below 50 per cent. The incubation periods varied from nine to 31 days depending upon the temperature, as the night temperatures were often below the minimum effective temperature for incubation of the eggs.

Larval development was largely dependent upon temperature since the food furnished ample moisture and the young larvae are not exposed until a week or ten days old. The feeding period required from 23 to 28 days and the pupal period from 10 to 11 days. The minimum temperature during the night was often below the minimum effective temperature for development. Freezing temperatures, which killed the plants, apparently did not injure the larvae.

Literature Cited

1914. Parks, T. H. Effect of temperature upon the oviposition of the alfalfa weevil (*Phytonomus posticus*, Gyllenhal). Jour. of Econ. Ent. 7:417–21.

1927. Reeves, G. I. The control of the alfalfa weevil. U. S. D. A., F. B. 1528:1–22.

1920. Reeves, G. I., Chamberlin, T. R., and Pack, K. M. Spraying for the alfalfa weevil. U. S. D. A., F. B. 1185:1–20.

1929. Sweetman, H. L. Field studies of the physical ecology of the alfalfa weevil. Wyo. Agr. Exp. Sta. Bul. 167:1–31.

THE WHITE BIRCH LEAF MINING SAWFLY, *PHYLLOTOMA NEMORATA* FALLÉN IN NEW YORK

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Abstract

White birch in our northeastern forests is being severely injured by the European leaf mining sawfly, *Phyllotoma nemorata* Fallén. This leaf miner was first reported in New York in 1930. In 1931 it has been found throughout most of the Adirondack State Park Area; and its further spread is likely to be rapid. This insect is easily distinguished from another European leaf mining sawfly, *Fenusa pumila* Klug, by the following characteristics: 1. Leaves mined by *F. pumila* are usually crumpled, those mined by *P. nemorata* usually retain their normal form; 2. *F. pumila* abandons the mined leaf when fully grown and transforms or hibernates in the soil, *P. nemorata* hibernates and transforms within a circular, flat, cocoon-like cell or hibernaculum constructed by the larva within the mined leaf. Where it occurs, *P. nemorata* may easily be found and identified by this hibernaculum from September to June, in the mined leaves on the ground.

In ornamental plantings, and in the forests of Northern New York, Northern New England and Eastern Canada, white birch is being severe-

ly injured by the European leaf mining sawfly, *Phyllotoma nemorata* Fallén (*Phlebatrophia mathesoni* MacGillivray). This leaf miner has only recently commanded the attention of entomologists as a forest pest of outstanding importance. During August and September of the past two years, the leaves of white birch in many sections of northeastern New York have been so completely browned by the work of this insect that entire hillsides appeared as if the foliage had been scorched by fire.

This leaf miner seems to have been first reported in America from Pictou, Nova Scotia in 1908; but it aroused little concern until 1927, when it was found to be causing severe injury to white birch in the forests of eastern Maine. In 1928, however, it was found to have spread westward across the states of Maine and New Hampshire and Southward into parts of Massachusetts.

This insect was first reported from northeastern New York in 1930 (N. Y. State Museum Circular No. 6); but the intensity of the infestation at that time in large stands of young white birch northeast of the higher Adirondacks, apparently could have resulted only from an infestation of several years standing. No general scouting work for this insect was done in New York in 1930; but in 1931, it has been found throughout the greater part of the Adirondack State Park Area; and, since it seems to have spread from eastern Maine with surprising velocity, it seems likely that it will very soon extend its range to all parts of the State, and even into neighboring states wherever white birch and gray birch occur.

While *Phyllotoma nemorata* will attack all species of birch, it exhibits a decided preference for white birch and for gray birch. Dr. H. B. Peirson, State Entomologist of Maine, and his associates of the Maine Forest Service, have found that injury to the foliage of white birch by this leaf miner may retard twig growth by as much as 80%, and may reduce the width of annual rings, or the growth increment in badly infested trees as much as 50%.

In the Adirondack State Park Area, New York has many thousands of acres of forest land that was denuded by fire about twenty-five years ago. This burnt over land affords an excellent demonstration of the processes which govern natural reforestation in that region. White birch is an important element in the succession of plant species which, if undisturbed, would determine the character of the future mature forests there. The handicap imposed upon white birch by this leaf miner, however, may well affect profoundly the composition of these future forests.

While this leaf miner will apparently be rather easy to control in

ornamental plantings, it will probably be troublesome enough in such situations at best; and this, with its status as a forest pest will make it of general interest for favorably situated entomologists to follow its progress, as it spreads further across New York, and on into other states.

Another birch leaf mining sawfly of European origin, *Fenusa pumila* Klug, is well known to most eastern entomologists because of its very conspicuous injury to the foliage of gray birch, and occasionally to that of white birch in late spring, and often again in late summer and autumn. These two birch leaf miners, however, may easily be distinguished by two very convenient field characters.

1. Leaves mined by *Fenusa pumila* are usually crumpled. Leaves mined by *Phyllotoma nemorata* usually retain their normal form.

2. The larva of *Fenusa pumila* leaves the mine when fully grown, and hibernates or undergoes its transformations within a cell made in the soil beneath the infested trees. The fully grown larva of *Phyllotoma nemorata*, however, constructs a circular, flattened cocoon or hibernaculum between the upper and the lower membranes of the mined leaf, and it passes the winter and undergoes its transformations within this hibernaculum in the fallen leaf.

Phyllotoma nemorata has one brood per year in Northern New York; but it is said to have two broods per year in England, and it may return to that habit when it reaches the central and southern parts of this State. The adults are black, about five millimeters long, and only females are known. The eggs are deposited in July, in slits cut in the teeth at the margins of the leaves; and while several larvae in the same leaf are said occasionally to attack and kill one another, it is not unusual to find two or three, and sometimes even as many as five hibernacula in a single leaf. Where it occurs, this leaf miner should be easily found and identified by its hibernacula at any time from late September or October to June, in the fallen leaves on the ground.

THE STATUS OF THE EUROPEAN CORN BORER IN THE UNITED STATES IN 1931

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ABSTRACT

The most serious spread of the corn borer (*Pyrausta nubilalis* Hubn.) discovered during the season of 1931 was in New Jersey where infestation was found for the first time scattered over about one-half of the State. Other isolated infestations situated at considerable distances from the regulated areas were, in Virginia—one, Kentucky—one, and two in Wisconsin.

During the year 1931, in the North Central States area, the annual infestation survey demonstrated that a decided increase in the numbers of the European corn borer had occurred generally throughout the territory surveyed, the borer population being approximately two and one-half times that present in the same territory in 1930. This apparently was due to a combination of causes; namely, favorable hibernating conditions in the winter, 1930–31, propitious conditions for larval establishment in the summer of 1931, and last but not necessarily least the natural reaction of insect life in general to better weather conditions after the drought of 1930. Distinct commercial losses from corn borer attack occurred to field corn in the northwestern Ohio district in general, and to sweet and field corn in the Lake Ontario district of New York.

In the Eastern States area, increases in borer population are known to have occurred locally in southern Massachusetts and on Long Island, accompanied by appreciable economic losses to sweet corn.

Experimental results obtained with insecticides applied to corn have demonstrated the practical feasibility of applying the more effective of such insecticidal materials to corn of high market value, as a protective control measure. Best results, to date, have been secured with paraffin oil-lead arsenate combinations, applied as liquids.

Approximately 371,000 additional imported parasites were liberated during 1931, bringing the total number of parasites liberated during the last 12 years to about 4,600,000. Several species of these parasites are known to have become permanently established. Field-recovery records indicate total parasitism by such species as ranging from less than 1 per cent to 30 per cent in different localities.

Field tests have demonstrated that certain corn varieties and strains were more resistant and tolerant to corn borer attack than others. The behavior of such varieties and strains has been consistent from year to year. The plant characteristics affecting resistance and tolerance are being sought.

Additional territory was included in the regulated area by a revision of the quarantine in January. This and two subsequent modifications during the year provided for more liberal movement under Federal supervision of restricted articles. Inspection of regulated articles was furnished, and market and road quarantine stations were maintained.

A review of the status of the European corn borer activities in the United States at the close of 1931 reveals encouraging progress in the

solution of the many biological, economic, control, and regulatory problems imposed upon agriculture by the presence of the pest in this country. Such progress refers more particularly to the projects relating to mechanical control, cultural practices, behavior, general and special biology, physiology, natural enemies, insecticides, chemotropism, and resistant or tolerant varieties and strains of corn.

DISPERSION OF THE CORN BORER DURING 1931. During the summer of 1931 scouting was done to determine corn borer infestation outside of the previously known infested territory. This consisted of a thorough examination of cornfields in the towns just beyond the periphery of the regulated section, along river valleys and main lines of travel. In general, the spread as determined by this survey was confined to towns adjacent to or nearby the regulated area. Exceptions were isolated infestations in two adjoining townships of the two adjacent counties of Sheboygan and Manitowoc on Lake Michigan in Wisconsin, three infestations along the Ohio River in Ohio, Kentucky and Indiana, and a single find on the Delmarva Peninsula section of Virginia near the Maryland line. The single and two generation strains have overlapped in eastern New York. The two generation corn borer has dispersed northwestward into Vermont and southerly into New Jersey, where many new infestations were discovered scattered over about one-half of the State.

STATUS OF INFESTATION AND CROP LOSS. *North Central States Area (One-generation):* In the North Central States area, comprising the infested portions of Michigan, Indiana, Ohio, Pennsylvania, and New York, the annual infestation survey to determine corn borer abundance in the late summer of 1931 demonstrated that throughout the surveyed territory there had occurred an increase which made the borer population approximately two and one-half times that present in the same territory in 1930 (25 versus 10 borers per 100 plants). This survey was conducted in cooperation with the Ohio Agricultural Experiment Station.

The territory surveyed comprised those counties in the area where during preceding seasons the borer population had equaled or exceeded an average of 5 borers per 100 plants. A total of 59 counties, involving 1,285 cornfields, was included in the survey.

An increase in the numerical abundance of the borer occurred practically throughout the entire territory examined. Three counties, out of the group of 59 counties examined, revealed significant decreases when compared with 1930 infestation data from the same counties. In fact, 1931 was the only year on record in which (beginning with 1925)

pronounced increases in borer abundance had developed throughout such a large portion of the territory.

Interest had been displayed in the possible adverse effects of the drought of 1930 upon the corn borer in 1931. It will be recalled that the unfavorable climatic conditions prevailing in 1930 caused a decrease of approximately 25 per cent in the borer population of this North Central States area in that year, as compared with the preceding year. Comparisons of the 1929 and 1931 infestation data show that the 1931 borer population is more than twice that of 1929, on an average, in the same counties (25 versus 12 borers per 100 plants), and in general the sharp decline observed in the 1930 borer population level was more than offset by the increases in 1931.

The more important points developed during the 1931 infestation survey, as well as an indicative comparison with similar surveys in the same counties during preceding years, are shown in Table 1, taken from the report of K. W. Babcock, in charge of the population project:

TABLE 1. COMPARISON OF EUROPEAN CORN BORER POPULATION IN THE TERRITORY SURVEYED OF THE NORTH CENTRAL STATES AREA, AND FOR EACH STATE, DURING THE SEVEN-YEAR PERIOD 1925–1931. (BASED UPON COMPARISONS OF COUNTY AVERAGES FOR EACH YEAR)

State	Counties	Borers per 100 plants in—						
	Number	1925	1926	1927	1928	1929	1930	1931
Michigan	14	1.18	11.80	24.90	15.95	17.91	14.11	21.17
Indiana	4	*	*	*	.46	.91	1.56	7.94
Ohio	25	3.18	9.13	6.85	10.76	20.63	8.52	28.02
Pennsylvania	3	1.91	8.85	14.15	2.64	4.92	2.94	1.09
New York	13	1.82	5.82	7.34	14.08	14.10	24.40	68.75
Area surveyed	59	2.02	8.90	13.31	8.78	11.69	10.31	25.39

*No survey.

Mr. Babcock reports that the principal influences contributing to the increase of borer population in the North Central States area in 1931 may be summarized as follows:

1. Favorable conditions for overwintering larvae, allowing them to recover from adverse effects of 1930 drought.
2. Favorable conditions for moth flight and the deposition of eggs.
3. Absence of unfavorable climatic phenomena during the egg and young larval periods, such as heavy showers and high winds. (The percentage of larval survival in 1931 was practically twice that of 1930).
4. High temperatures and timely rains, throughout much of the territory under the survey, during the period of maximum corn growth, thus providing vigorously growing food plants, and contributing to improved conditions for larval establishment and survival.

It is quite possible also that at least a part of the increase in population observed was in harmony with a somewhat general reaction noted among insect pests to the more favorable weather conditions in 1931, after the severe drought of 1930.

Two districts of the North Central States area represented the maximum concentration of borers for the territory surveyed, (1) the northwestern Ohio counties of Wood, Hancock, Seneca, and Sandusky, in an area located some distance removed from Lake Erie and lying south of the previous center of infestation, and (2) the counties of Jefferson, Oswego, Wayne, and Monroe, situated along the eastern and southern shores of Lake Ontario in New York. Distinct commercial damage occurred in both of these districts.

In the northwestern Ohio district the infestation was characterized by an unusually uniform distribution of the borer population, marked by an absence of heavy concentration in any particular field or fields. The maximum borer population in one field under observation was slightly more than 500 borers per 100 plants. However, there were a great many fields in the four counties listed which closely approached this degree of infestation. In such fields the injury and economic loss due to corn borer attack was visually evident. These four counties can be distinctly classified as "corn" counties, since they represent a total of approximately 290,000[1] acres of corn.

The adjacent counties of Ottawa, Lucas, Henry, Putnam, Allen, Hardin, Wyandot, Crawford, Huron, and Erie represented approximately one-half of the borer density, on an average, of that in the four counties representing the maximum concentration for the northwestern Ohio district. In the remaining counties of this district under the survey, comprising those in the third "ring" of counties from the center of infestation, the borer density was approximately one-sixth, on an average, of that in the center of this district.

In the Lake Ontario district of New York substantial losses were suffered by the growers of sweet corn, particularly in the counties of Jefferson, Oswego, Wayne, and Monroe, with less serious but appreciable damage to field corn and silage corn. A special survey conducted by Mr. Scott of the Silver Creek station disclosed specific instances where entire fields of sweet corn, intended for canning purposes, were infested by the corn borer to such an extent that the canning factories declined to accept the crop. Several of such fields were discarded, to be ultimately plowed under, and no revenue was secured therefrom. Crops of sweet corn from other fields in this category were placed in silos, to

[1]On basis of 1930 "Census of Agriculture."

escape a complete loss. One canning company operating in Oswego and Ontario Counties reported that 200 acres of sweet corn grown by their company were infested to such a degree that it could not be utilized for canning, and was placed in silos as a last resort. Another canning company in Wayne County reported a similar partial loss of 60 acres of sweet corn. Individual farmers in the counties of Monroe, Ontario, and Livingston sustained losses ranging from 10 to 15 per cent of the sweet corn ears, refused by the canning factories on account of corn borer infestation. Proprietors of roadside stands in Monroe County reported losses of an undetermined extent, through the necessity of discarding sweet corn ears infested by the borer, which they or near-by farmers had grown for the roadside trade.

In the remainder of the northwestern New York district under the survey, comprising the counties of Niagara, Orleans, Genesee, Wyoming, Erie, Chautauqua, and Cattaraugus, the borer density was approximately one-third, on an average, of that in the four counties representing the maximum of this district. In the eastern New York district under the survey, comprising the counties of Albany, Saratoga, Schenectady, and Rensselaer, the borer density was approximately three-fourths, on an average, of that of the four counties along Lake Ontario representing the maximum concentration of the State.

Eastern States Area (Two-generation): In the Eastern States area, comprising principally the eastern and southern portions of New England and the eastern end of Long Island, no area-wide infestation survey was conducted in 1931, because of the lack of funds. Consequently, no reliable statements can be made respecting the density of infestation in that general area during 1931 compared with preceding years. An intensive specialized survey in a quadrat 25 square miles in area in the Berkley, Massachusetts district, by Mr. Hodgson of the Arlington station, disclosed an increase of approximately 15 per cent in borer abundance, in this typical section of southern Massachusetts.

An examination of 36 cornfields at the eastern end of Long Island (Suffolk County), by Mr. Kimport of the Bayshore station, indicated that an increase in borer density amounting to approximately three and one-half times (382 versus 110 borers per 100 plants), on an average, had occurred in the same or nearby fields compared to a similar survey in 1930. One field in this district showed 100 per cent of the plants infested, with an average of 30 borers per plant. Based upon the samples examined there were, on an average, in Shelter Island township 244 borers per 100 plants, in Southold 624 borers per 100 plants, in Easthampton 597 borers per 100 plants, and in Southampton 799 borers per

100 plants. It is apparent that this eastern end of Long Island constitutes an important source of infestation for the adjacent Atlantic seaboard. Supplementary field observations and surveys by Mr. Kimport in plants other than corn, in this same district, disclosed the presence of the borer in many of the common vegetables, flowers, and weeds. A special survey in 97 fields of lima beans, totaling 146 acres, revealed corn borer infestation in 61 fields of this group. Although many of the lima bean pods had been harvested at the time of the survey, approximately 3⅓ per cent of the pods and 18 per cent of the plants, on an average, were found to contain the borer.

Incidentally, the infestation survey conducted by Mr. Kimport in the one-generation district at the western end of Long Island (counties of Queens and Nassau) demonstrated that the borer density had increased in this district approximately three times during 1931 (22 versus 7 borers per 100 plants), on an average of the plants examined, as compared with a similar survey in the same or near-by fields during 1930.

With respect to commercial losses due to corn borer attack in the Eastern States area, it may be stated that no surveys have been made with the definite object of determining these points, but general observations demonstrated heavy losses in sweet corn, especially in the late-planted fields, in the southern part of Massachusetts. The high borer populations mentioned as existing in corn in the eastern end of Long Island were accompanied by appreciable although undetermined economic losses.

INSECTICIDE INVESTIGATIONS. Experimental results secured with insecticides during 1931, and for the last three seasons, have demonstrated the practical feasibility of applying the more effective insecticidal materials to corn of high market value as a protective corn borer control measure. The experimental work on this project has involved an exhaustive testing of the entire field of such insecticidal materials giving any promise of effectiveness. As reported by Doctor Batchelder of the Arlington, Massachusetts station[2], the use of a 1 per cent light paraffin oil emulsion as a carrier for a suspension of lead arsenate, applied in the liquid form, has consistently produced a degree of control ranging from approximately 60 to 90 per cent, expressed in terms of reduction of the larval population of the plot, under the two-generation conditions existing in the New England area. These investigations are being continued, emphasis being placed upon the perfection of this

[2]Batchelder, C. H., and Questel, D. D. 1931 Insecticidal Control of the European Corn Borer: The Problems Involved and Some Experimental Results. Jour. Econ. Ent. 24:1152–1167.

paraffin oil-lead arsenate combination, the determination of the best time and method of application with respect to the seasonal development of the plant and the corn borer, and the relation between the growth habit and general physiology of different varieties of corn as they affect spray coverage.

INVESTIGATIONS OF LETHAL LOW TEMPERATURES. Information was obtained during 1931 concerning the duration of the period to kill fifth-instar corn borer larvae when exposed to freezing temperatures. Exposure of the larvae to minus 25 degrees F. during 10 minutes was found to effect complete mortality, 12 minutes of exposure to minus 20 degrees F., was fatal, 20 minutes exposure killed the larvae at minus 10 degrees F., 150 minutes of exposure was required to kill all the larvae at zero Fahrenheit, and 65 hours of exposure to plus 15 degrees F., caused death.

When the larvae occupied tunnels in the cob of green sweet corn, packed in standard bushel boxes with slat tops and stacked in a cold storage room at zero F., 8 days of such storage were required to effect complete mortality. Processing ears of "Whipple's Yellow" sweet corn during 4 hours by means of a "plate froster," operating at minus 22 degrees F., was found efficient in killing all larvae infesting the cob pith, as well as all other parts of the ear.

Establishment of these periods of lethal exposure has a direct application to the commercial processing of green sweet corn, and provides a guide for their sterilization by means of cold for quarantine regulatory work.

NATURAL ENEMIES. Approximately 371,000 imported corn borer parasites were liberated in the infested areas of the United States during 1931, involving 18 different species. For the 12-year period 1920 to 1931, inclusive, a total of approximately 4,600,000 of these parasites have been liberated. Twenty different species of parasites have been represented, such species originating in Europe and in the Orient. Twelve of these species have been recovered in the field under circumstances indicating their possible permanent establishment.

Mr. Jones and his associates at the Arlington, Massachusetts station report that in the summer of 1931 field collections to determine the imported parasite population in 27 typical towns of the Eastern States area revealed over 30 per cent parasitism in the samples collected from 6 of the towns, and that gratifying data upon degree of parasitism and rate of parasite dispersion were secured from the entire group of 27 towns. Incidentally, "bulk collections" of cornstalks from given acreages were placed in screened enclosures to secure adult parasite emer-

gence. In one of these bulk collections adult parasites emerged at the rate of 9,515 parasites per acre, and from another lot, collected 2 miles from any liberation point, at the rate of 4,896 parasites per acre. Parasites had emerged in the fields before the cornstalks were collected, and a careful check of parasite cocoons and puparia within the cornstalks indicated the emergence of nearly twice as many parasites per acre as are shown in the figures previously given.

In the North Central States area Mr. Baker and his associates at the Monroe station report that the parasite-recovery collections of 1930 indicate a total parasitism by the imported species ranging from a trace to 21 per cent, in the general vicinity of the original liberation point at eight of the more important liberation points in that area. Data from the recovery collections of 1931 in this area will not be available until the spring of 1932.

Larval Survival; Resistance and Tolerance of Corn. Continued field tests, during 1931, of commercial varieties and special strains of corn, by Mr. Patch of the Sandusky station, in cooperation with the agronomists, corn breeders, and soils specialists of the Illinois and Ohio Agricultural Experiment Stations, the U. S. Bureau of Plant Industry, and the Illinois Natural History Survey, have demonstrated consistently that certain of the corn varieties and strains were more resistant to the corn borer than others, as expressed in terms of relatively low larval survival (i. e., number of mature borers developing from each 100 eggs deposited), when grown under equivalent conditions of exposure to corn borer infestation, soil type, soil productivity, and other cultural influences. The strains possessing marked resistance have been consistent in this characteristic from year to year. Investigations, in cooperation with various specialists, will be continued to determine the plant influences responsible for this consistent resistance, with the objective of utilizing this feature as an aid to corn borer control.

In order to judge the economic value of any particular variety or strain of corn, as a factor in corn borer control, it is necessary to consider the tolerance as well as the resistance of such varieties or strains to corn borer attack. For our purpose, the most important factor of "tolerance" may be defined or measured in terms of the yield and quality of the crop. With an equal number of borers per plant, the yield of a tolerant strain of corn is greater than the yield of a less tolerant strain, even though the yield of both strains might be the same in the absence of corn borer infestation. Another important factor of tolerance is the degree of stalk breakage, in the presence of corn borer infestation. As a result of a review of the reports of 1931 by Mr. Patch, and by Mr.

Schlosberg of the Toledo station, it may be stated that certain of the varieties and strains tested have exhibited more tolerance to corn borer attack than others, but that this tolerance may or may not be combined with resistance. In certain of these tests, conducted in cooperation with the agencies mentioned previously and with the U. S. Bureau of Agricultural Engineering, an important factor in tolerance exhibited appeared to reside in the rigidity or ruggedness of the stalk, which permitted the stalks of certain of the high yielding strains to escape with a minimum of breakage below the ear, thus allowing the ears every opportunity for complete development, and later contributing to efficient harvesting by hand or machinery owing to the upright position of the stalks. These results were secured in experimental plots where varying levels of borer population were induced by manual infestation. It is hoped that continued investigations of the influences affecting tolerance to corn borer infestation in the corn plant will lead to an economic utilization of the results in corn borer control.

Experiments to Determine Degree of Damage. Field experiments were continued in 1931 by Mr. Patch at Sandusky and by Mr. Schlosberg at Toledo, in cooperation with the agronomists and soils specialists of the Ohio Agricultural Experiment Station and the U. S. Bureau of Plant Industry, with the objective of associating borer population and the degree of damage and economic loss occasioned by the corn borer when infesting widely divergent typical or special types, varieties, and strains of field and sweet corn under different conditions of soil type and soil productivity. Expressed in another manner, this project is designed to yield information enabling us ultimately to translate figures upon borer population into terms of crop loss, with proper allowance for the variations in loss caused per borer per plant due to varietal differences and different cultural and environmental conditions affecting the growth and yield of corn. Essentially the plot technique in these field tests consists of manually infesting replicated, uniform-sized, and adjacent plots of corn with a sufficient number of corn borer eggs, to produce progressively higher levels of borer population per plant. In each series, one of the plots contains natural infestation only, but otherwise receives the same treatment as the manually-infested plots. Usually the series of progressive levels of borer population has consisted of adjacent plots containing an average of approximately 5, 10, 15, 20, and 30 borers, respectively, per plant, accompanied by a plot containing natural infestation only. In some of the field tests, additional or different ranges of borer population levels have been employed. Since the same variety of corn in any series is all planted on the

same date, in nearly uniform soil receiving a uniform fertilization, and given the same cultural treatment throughout a season, this technique accounts for all measurable variables excepting the number of borers per plant. Moreover, the plots are replicated to equalize possible minor soil differences and to enable proper adjustments of any other possible minor variables that may develop.

Information upon the loss occasioned by the borer per plant, under the varying conditions encountered in actual corn culture, must await the analysis of the experimental data now on hand, plus a continuation of the field tests.

QUARANTINE. During the year modifications of the quarantine were made as conditions required or permitted, removing restrictions considered no longer necessary and providing for more liberal movement of articles under Federal supervision. On January 23, the quarantine was revised to include more area in Connecticut, Maine, Massachusetts, New York, Indiana, New Jersey, Ohio, Pennsylvania, and West Virginia, to transfer some areas from the one-generation to the two-generation regulated areas and to release from restriction part of a county in New Jersey and two entire counties in New York State. On July 24 a modification became effective removing from the two-generation regulated area, part of Hudson County, New Jersey. On August 15 the quarantine was further modified omitting restrictions on articles shipped on through bills of lading between points in the same regulated area through non-regulated territory, or shipped on a through bill of lading from the one-generation regulated area to the two-generation regulated area, through non-regulated territory. In addition, provision was made for authorizing movement, under permit and seal, of trucks and other road vehicles moving between points in the regulated areas but passing through non-regulated territory en route.

Inspectors have supplied the public with service enabling them to distribute their eligible produce. Inspection stations in the principal markets in the two-generation area were conducted as previously; namely, at Boston, Massachusetts; Portland, Maine; Providence, Rhode Island; Hartford, Connecticut; and New York City, New York. In the wholesale markets of these cities, inspection was maintained on restricted farm produce and flowers. In the Boston and New York markets lima beans showed severe infestation. In the case of the former, the lima beans originated mostly from a section near New Bedford, Massachusetts. In New York they originated on Long Island. Lima beans were more seriously infested than any other farm products which

are regulated on account of this quarantine. A summary of the articles certified and permitted during the season of 1931 follows:

CERTIFIED

Asters		Chrysanthemums		Dahlias		Gladoli
Blooms	Plants	Blooms	Plants	Blooms	Plants	Blooms
562,138	1,096	597,290	2,065	305,769	256	1,180,028

CERTIFIED

Beans			Beets	Rhubarb	Celery*
Lima	Bushels Shell	String*	Bunches	Bunches	Crates
103,577⅜	5,174	131*	457,616½	15,013	103*

PERMITTED

						Green corn Pkgs.	Broom corn Bales
1,189½	1,753	2,804*	49,211	406	5,241*	41,918	131

*String beans and celery certified or permitted in compliance with Canadian regulations.

In cooperation with the states involved, approximately 250 quarantine road stations were operated to prevent the movement of uncertified and prohibited articles out of the regulated area. Inspectors at road stations operating in the one-generation area stopped 8,846,259 automobiles and intercepted the following amounts of corn: 2 tons, 1,935 lbs., 6 cars, 1 load, 6 packages, and 379,041 ears. These were not allowed to be transported beyond the quarantine line. In the two generation area inspectors at road quarantine stations stopped 7,412,366 automobiles and made the following interceptions:

	Ears	Lbs.	Blooms	Bu.	Bags	Stalks	Bales	Bunches	Plants	Pkgs.
Corn...	119,303									
Beans..		13,145		697	82					14
Beets...					4			26,052		50
Rhubarb		31				3,999				
Broom Corn.							1			
Galdioli			52,322							1
Dahlias			18,894							1
Asters..			17,772						1	3
Chrysan.			708							1

If these articles were not properly certified, they were not allowed to proceed, except in a few cases when an official had time to properly inspect the restricted products. Corn was not allowed to be carried beyond the quarantine line after June 14 unless there was satisfactory proof of its originating outside of the quarantined area.

The quarantine has been vigorously enforced through the year, and although the spread of this insect has not been entirely prevented, it is believed that it has been greatly retarded.

CALCIUM FLUOSILICATE COMPOUND IS NOT CALCIUM FLUOSILICATE

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ABSTRACT

The difference between true calcium fluosilicate and "calcium fluosilicate compound" is pointed out. It should be remembered that entomological results obtained with these materials should be reported separately and should not be compared as they are very much different in chemical composition. Analyses and compositions of these materials are shown.

Considerable attention has been directed in the last few years to the investigation of the insecticidal properties of the fluorine compounds, of which there are several classes, differing considerably in solubility and fluorine content.

One of the most important of these classes is known as the fluosilicates, the general formula of which may be represented by M_2SiF_6, $MSiF_6$, etc. where M represents mono- and bivalent elements respectively. Some are anhydrous and stable, whereas others crystallize with from 2 to 6 mols of water of crystallization and are not stable at slightly elevated temperatures. Thus, magnesium fluosilicate ($MgSiF_6 . 6H_2O$) loses at 100°C., not only water of crystallization but also silicon tetrafluoride. Many of the fluosilicates are very soluble, but a few, e.g., those of sodium, potassium, and barium, are insoluble enough to have found some use as insecticides on field crops.

In recent years entomological literature has contained many references to the use of "calcium fluosilicate." Actually Marcovitch appears to be the only investigator who has tested the insecticidal value of true calcium fluosilicate. (Bulletin No. 139, Univ. of Tenn. Ag. Exp. Sta. March 1928.) The material being used by most entomologists is a complex by-product of phosphate fertilizer manufacture containing at most only a small proportion of calcium fluosilicate, and it is the purpose of this paper to call attention to the serious confusion that is certain to arise if the incorrect designation is continued.

Pure calcium fluosilicate is difficult to make because of its tendency to decompose into calcium fluoride. The Insecticide Division has been unable to find a commercial source of true calcium fluosilicate. Marcovitch appears to have obtained a sample of reasonable purity from one company, but this company can not supply it now. A sample of a high degree of purity was made in this laboratory by precipitation with alcohol from a solution of calcium chloride and hydrofluosilicic acid.

The fine white precipitate was filtered and dried in a desiccator over calcium chloride.

When heated in an oven at 92° C. for 20 hours the product lost weight corresponding to two mols of water of crystallization and further heating at 100°C. for 24 hours and then at 120°C. for 24 hours produced no further appreciable loss in weight.

Hydration again took place when the dry material was allowed to stand in a moist atmosphere.

The result obtained on titrating the fluosilicate radical with standard alkali also agreed with the supposition that this material is a dihydrate, because it indicated a purity of 98.9 per cent $CaSiF_6.2H_2O$.

The solubility of this compound was determined, and found to be 10.58 g. per 100 c.c. of solution. This does not agree at all with the value given by Marcovitch, who says that 1 g. of calcium fluosilicate (presumably the dihydrate) dissolves in 2.9 grams of water. Regardless of this discrepancy, it is certain that true calcium fluosilicate is very much more soluble than sodium fluosilicate, and hence there is practically no chance that it can ever be used for direct application to growing plants. Marcovitch reports experiments with three other supposed calcium fluosilicates and one "calcium fluosilicate compound." It is the latter compound that has been so largely experimented with by many entomologists. It is a by-product of phosphoric acid manufacture and the degree to which it differs from pure calcium fluosilicate is clearly shown by the following figures:

	"Calcium fluosilicate Compound"	Calcium fluosilicate theory for $CaSiF_6.2H_2O$
	Per cent	*Per cent*
Calcium, Ca	16.4	18.35
Fluorine, F	11.6	52.21
Fluorine, F total water soluble	9.8	52.21
Phosphorus pentoxide, P_2O_5	27.3	——
Iron and aluminum oxides, Fe_2O_3	18.2	——
Silicon, Si	Present	12.95
Water, H_2O	Present	16.49

The form in which the fluorine is present in the compound is not definitely known. If it exists wholly as $CaSiF_6.2H_2O$ there is about 22 per cent of that compound present. Extraction with water and subsequent titration with alkali gives the equivalent of only 18.8 per cent of that compound (even less according to Marcovitch's figures), but of course this behavior may be due to interaction with other constituents of the mixture. The pH values of saturated solutions of these compounds were not determined but both were strongly acid in reaction.

Therefore, it should be remembered that chemically there is very little relationship between calcium fluosilicate and the so-called "calcium fluosilicate compound," and entomologists should be careful not to report results obtained with the "compound" as representing the action of "calcium fluosilicate."

THE CONTROL OF THE CABBAGE MAGGOT (*PHORBIA BRASSICAE* BOUCHÉ) ON RADISHES

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ABSTRACT

A comparison between bichloride of mercury and calomel in reference to their efficiency in controlling the cabbage maggot (*Phorbia brassicae*) on radishes indicates that a dust consisting of calomel four per cent plus gypsum 96 per cent gives as good results as bichloride of mercury (one ounce in 10 gallons of water) and is cheaper and easier to apply.

The object of the experiments carried out in 1931 with radishes was to determine the relative efficiency of calomel (monochloride of mercury) and bichloride of mercury as agents in the control of the root maggot, *Phorbia brassicae* Bouché. Bichloride of mercury is at present the most commonly used material for controlling this insect in Connecticut, but its use on radishes may be a questionable practice in view of its poisonous qualities. Calomel has been recommended for the control of other insects in past years, and its efficiency as a controlling agent for the larvae of *Phorbia brassicae* was demonstrated by Glasgow (1929). This author found that not only was calomel a good insecticide but also that it was not injurious to the plants. Bichloride of mercury is sometimes injurious to cucriferous plants, especially cauliflower. Glasgow further states that this material is to a certain extent effective in checking such seedbed diseases as clubroot and damping off.

It is essential to obtain more nearly complete control of the root maggot on radishes than on cabbage or cauliflower, for a very slight injury to the root system of one of the latter plants might not greatly effect the production of a good head, whereas a single maggot burrow in a radish may well make it unsaleable or at least markedly reduce its value.

According to the results obtained by Glasgow on cauliflower in the seedbed, calomel may be effectively applied as a suspension in water at the rate of one ounce in 10 gallons, as a four per cent dust mixed with gypsum, drilled into the row with the seeds, or coated on the seeds. The four per cent dust gave 100 per cent clean plants with two applications;

the suspension in water at the rate of one ounce in 10 gallons gave 98 per cent clean plants with two applications, and the methods of coating the seed and drilling in with the seed gave 100 per cent clean plants.

In attempting to control the root maggot on radishes calomel was compared with bichloride of mercury. The calomel was applied in three different ways: (1) As a suspension in water at the rate of one ounce in 10 gallons; (2) As a dust mixed with gypsum, the calomel making four per cent of the mixture by weight, and the material being applied to the surface of the soil about the plants; (3) The same mixture as (2) drilled into the soil with the seeds. The bichloride of mercury was used as a solution containing one ounce in 10 gallons of water. The plots were laid out in a latin square arrangement, five plots to a row (Fig. 41). This gave five series of five plots each, one series for each of the insecticidal combinations and one series of check plots. Each plot consisted of four rows three feet in length. Two sets of such plots were used for each variety of radish planted, one set being treated twice and one set three times, except, of course, where the material was drilled in with the seeds.

Scarlet Globe, White Icicle and Black Spanish varieties were planted between April 21 and April 29, and as soon as the plants were well above ground they were thinned to a distance of three inches apart. The plots receiving two applications of the insecticides were treated May 9 and May 19. The plots receiving three applications were treated May 12, May 19 and May 27. The Scarlet Globe and White Icicle varieties were pulled May 29 to June 3, and the Black Spanish variety was pulled June 25.

In determining the effectiveness of the materials used, all plants showing any maggot injury whatsoever were classified as infested. All others were classified as clean. A fungus disease, *Aphanomyces raphani*, severely injured the Icicle and Spanish varieties, but such infected roots were considered as clean if they showed no maggot injury. The results are given in the accompanying tables, the figures indicating the per cent of clean plants and total number of plants examined.

Although the bichloride of mercury treatments gave slightly better results in most instances, the difference between these and the results of some of the other treatments are of little practical significance. The ease with which the calomel-gypsum dust may be applied and the cheapness of the mixture make it preferable in view of the fact that the results obtained by using it are quite as good as those obtained by any other method. There is an uncertainty of obtaining an even distribution of poison by drilling in the calomel-gypsum with the seeds, and in these experiments the material was strewn in the furrow by hand. The drill-

ing method appears promising if these difficulties can be overcome. Calomel settles in water too quickly to make the application of a suspension efficient, and this can hardly be recommended. The poor results secured with the Black Spanish variety are presumably due to an infestation of the second brood of the maggot, as the plants were pulled June 25, about one month after the last application of the insecticide. The third application on this variety did exert some beneficial effect, as the figures in the second table indicate.

Bichloride of mercury 1–1280	Check	Calomel—gypsum drilled	Calomel—gypsum dusted	Calomel 1–1280
Calomel 1–1280	Bichloride of mercury 1–1280	Check	Calomel—gypsum drilled	Calomel—gypsum dusted
Calomel—gypsum dusted	Calomel 1–1280	Bichloride of mercury 1–1280	Check	Calomel—gypsum drilled
Calomel—gypsum drilled	Calomel—gypsum dusted	Calomel 1–1280	Bichloride of mercury 1–1280	Check
Check	Calomel—gypsum drilled	Calomel—gypsum dusted	Calomel 1–1280	Bichloride of mercury 1–1280

FIG. 41.—Arrangement of plots

TABLE 1. CLEAN PLANTS, TWO TREATMENTS

Treatment	Scarlet Globe Total plants	Scarlet Globe Per cent clean	White Icicle Total plants	White Icicle Per cent clean	Black Spanish Total plants	Black Spanish Per cent clean
Bichloride of mercury 1–1280	287	82.3	298	86.5	252	41.7
Calomel 1–1280	272	76.0	314	82.9	248	37.0
Calomel—gypsum dusted	260	78.8	298	85.6	238	55.6
Calomel—gypsum drilled	236	82.6	299	80.0	274	47.5
Check no treatment	270	45.9	285	38.6	220	27.2

TABLE 2. CLEAN PLANTS, THREE TREATMENTS

Treatment	Scarlet Globe Total plants	Scarlet Globe Per cent clean	White Icicle Total plants	White Icicle Per cent clean	Black Spanish Total plants	Black Spanish Per cent clean
Bichloride of mercury 1–1280	302	95.0	200	93.5	272	79.8
Calomel 1–1280	338	88.3	203	92.6	262	69.1
Calomel—gypsum dusted	314	94.0	184	94.2	256	73.5
Calomel—gypsum drilled	246	92.0	304	90.0	267	38.6
Check no treatment	297	71.2	204	60.3	262	37.0

The much better results obtained with three treatments on the Scarlet Globe and White Icicle varieties are probably due to the lower

degree of infestation along the western border of the field where these plots were located. The check plots of these two varieties show much less infestation than in the plots treated twice, and this is more than enough to over-balance the increase in clean plants shown. Two treatments on radishes appear sufficient.

The possibility of a poisonous residue on the roots is of some interest. A sample was taken of all plots the last of May, a day or two before the plants were pulled, and the roots were washed in tap water to remove the dirt, as is done by market gardeners. An analysis of these roots by Dr. H. J. Fisher of the Station Analytical Laboratory, showed the presence of mercury as given in Table 3.

TABLE 3. MERCURY CONTENT OF RADISHES

Treatment	Per cent mercury
Bichloride of mercury 1–1280	0.00036
Calomel 1–1280	0.00004
Calomel—gypsum dusted	0.00000
Calomel—gypsum drilled	0.00000
Check, no treatment	0.00009

The check plots showed a trace of mercury, as did the calomel suspension plots, but in neither case can this be considered significant. Mercury treatment for root maggots has been carried on for some years in this field, and this may explain the presence of these minute quantities of the substance. Although the bichloride plots show a significant quantity of mecury by analysis, this is probably of little practical importance. The lethal dose of bichloride of mercury is 0.135 grams. Granting this mercury found on the radishes in the bichloride plots to be in the form of $HgCl_2$ (which may or may not be the case), it would take 61 pounds of radishes to produce a lethal dose.

NEW SPRAYS EFFECTIVE IN THE CONTROL OF THE LOCUST BORER

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Abstract

Results are presented of tests of sprays for the control of the locust borer (*Cyllene robiniae* Forst.), particularly on shade trees and in small plantations. Attention was paid to the effects of the sprays on the vegetation surrounding the bases of the trees as well as on the stems. Emulsions containing sodium arsenite, pine-tar oil and paradichlorobenzene, and orthodichlorobenzene were found to give a high degree of control when applied in the early spring while the young borers were present between the bark and wood. Later applications, after the larvae had penetrated the wood, were not so successful. The cost of application was found to be such as to make it feasible to protect shade trees and possibly trees in small plantations. As a preface to this paper, a brief résumé of literature is given of the work done by other entomologists during the past twenty-five years to control this borer.

Damage by the locust borer (*Cyllene robiniae* Forst.) to young yellow or black locust (*Robinia pseudacacia* L.) trees has been the subject of investigations for many years. According to Cotton (*2*), Forster mentioned the destructive work of this insect in New York State as early as the year 1766. For many years it has been a destructive pest in the southern Appalachians and in the Gulf region. In some cases it was thought to have been introduced into new localities in nursery stock. The borer apparently made its first appearance in Colorado in 1907 (*5, p. 8*). Within the past year it has been found in the Southwest in the States of Texas, New Mexico, and Arizona, and in the Northwest in the State of Washington.

Former Investigations. Hopkins (*6*) in 1906 cited thirty-nine references to literature relating to contributions of various entomologists on the life history, habits, distribution, and methods of control of this insect. Methods of control up to this time consisted principally of applying washes during the fall and winter months to kill the eggs and tiny larvae present in crevices of, or under, the bark, and of cutting out the infested trees during the summer. These washes consisted of powdered sulphur or whitewash mixed with a soap solution. In addition to these methods, Hopkins suggested the use of a poisoned bait to destroy the adult beetles in the fall. This bait consisted of sirup or honey mixed with arsenic. None of these methods of control proved to be very satisfactory.

Again Hopkins (*7*), in 1907, appears to have been the first to apply

kerosene emulsion during the dormant season for the control of this borer.

Washburn (*10, p. 95*), in 1907 and 1908, recommended the use of lead arsenate in a repellent wash made from powdered sulphur or crude carbolic acid, soap, and whitewash, to be applied during the fall months. From 4 to 6 pounds of lead arsenate to 50 gallons of wash was recommended.

In 1908 Houser (*8, p. 195*) suggested injecting carbon disulphide into the tunnels previous to the appearance of the adults and closing the tunnels with grafting wax.

Two years later Severin (*9, p. 123*) advocated that linseed oil be mixed with paint, also that hydraulic cement with water or milk be used as repellent in the fall. Gas tar was also tried, but there was the danger of burning the bark of the tree.

Garman (*4, pp. 110, 119*), in 1916, recommended the destruction of all goldenrod in the vicinity of plantations. Experiments with spraying sections of trees with both lead arsenate and lime-sulphur mixtures were unsuccessful in preventing oviposition and also in preventing the young grubs from entering the bark. According to Garman (*4, p. 120*), Niswonger obtained what seemed to be encouraging results by spraying sections of the trunk with concentrated lime-sulphur (1 part to 8 of water) in the fall immediately after the young grubs had penetrated the bark.

Craighead (*3*) appears to have been the first to recognize the value of early spring applications of arsenicals to kill the young borers beneath the bark. Previously entomologists confined their efforts with chemicals to fall treatments, with the exception of applications of carbon disulphide. Craighead found that arsenical sprays—(*a*) sodium arsenite or arsenate ¼ pound, water 5 gallons, and miscible oil 1 quart; and (*b*) ¼ pound of arsenical in 4 gallons of water to which 1 gallon of kerosene emulsion was added—applied about the time the leaves began to unfold gave excellent results.

One other contribution toward the control of this borer was made by Compton and Flint (*1*) in 1927. They suggested the use of sticky tree-banding material poisoned with a 50 per cent solution of sodium arsenite or sodium fluoride. The arsenite was found to act more quickly than the fluoride.

PRESENT INVESTIGATIONS. In response to requests for additional spray mixtures effective in the control of the locust borer, the Forest Insect Division of the Bureau of Entomology conducted tests during the summers of 1928 and 1929, in the vicinity of Asheville, N. C., as a part

of the program of work in cooperation with the Appalachian Forest Experiment Station.

Initial work included the application of certain arsenical sprays which had previously been tested and which had given promising results (*3*). The main objection to the use of these sprays was the danger in the handling of the poisons. Other emulsions were made with orthodichlorobenzene and with paradichlorobenzene and pine-tar oil, which were believed to be slightly more effective and at the same time safer to handle. All these solutions and emulsions were applied with a 3-gallon pressure spray pump, with the exception of an emulsion containing paradichlorobenzene and pine-tar oil[1], which was applied with a brush.

TESTS OF 1928. Tests were made during 1928 at two different periods. One series was made when the larvae first became active in the spring and while they were still between the bark and wood—that is, about the time the leaves unfolded. The other series was made after the larvae had penetrated the wood.

The trees in the plantation on which these tests were made were located on a fairly good site in a sandy, bottom-land soil. They were about 15 years old and averaged 5 inches d.b.h. and 16 feet in height. All the trees were well infested. A count of the borers present in the basal 6 feet of the stems of 20 of these trees revealed a total of 660, or an average of 33 borers per tree. This count was made on May 3, 1928, the date of the first spray treatment. Since these trees were fairly representative of the plantation as a whole, no further counts were made and the above figures served as a basis for estimating the percentage of control obtained in subsequent tests.

The effect of the sprays on the trees was checked first about two to three weeks after their application to note any immediate injury and again the following two springs to note any latent injury. The results noted in the table represent the final observations.

The following results were obtained when the chemicals were applied in the early spring before the larvae had entered the wood (Table 1):

(1) The use of sodium arsenite solution as a spray against the locust borer was very effective, giving a mortality of 97 per cent.

(2) Sodium arsenite plus kerosene emulsion was also very effective, resulting in a mortality of 99 per cent.

[1]The formula for this mixture was obtained from C. C. Hamilton, associate entomologist of the Agricultural Experiment Station, New Brunswick, N. J., who had used it for treating green logs to prevent bark-beetle attack. It was prepared by dissolving the paradichlorobenzene in the pine-tar oil after the latter had been heated to 130°F.

TABLE 1. EFFECT OF DIFFERENT INSECTICIDES ON YOUNG LARVAE BEFORE ENTERING THE WOOD. TESTS OF 1928 APPLIED ON MAY 3, 1928

Material	Strength	Number of trees treated	Probable number of borers			Estimated per cent mortality	Effect on tree
			Total	Dead	Alive		
Sodium arsenite Water	1 lb. 10 gals	20	660	640	20	97.0	None
Sodium arsenite Kerosene emulsion[1]	1 lb. 10 gals.	10	330	327	3	99.0	None
Kerosene emulsion[1]	Full strength	13	429	336	93	78.4	None
Crude orthodichlorobenzene	Full strength	1	33	33	0	100.0	None
Kerosene Orthodichlorobenzene	Equal parts	2	66	66	0	100.0	Killed
Orthodichlorobenzene emulsion[2]	Full strength	3	99	99	0	100.0	None
Orthodichlorobenzene emulsion[2] Water	Equal parts	3	99	96	3[3]	97.0	None
Orthodichlorobenzene emulsion[2] Water	1 part 2 parts	5	165	163	2[3]	98.9	None

[1]Soap ½ pound, kerosene 1 gallon, water 2 gallons.
[2]Whale-oil soap 1 pound, orthodichlorobenzene 1 gallon, water 1 gallon.
[3]Larvae penetrated wood.

(3) When kerosene emulsion was used alone, a mortality of only 78.4 per cent was obtained.

(4) Orthodichlorobenzene applied full strength was very effective. None of the trees were observed to have been injured as a result of the treatment. Although the effect of this solution on the ground cover was not noted at the time, subsequent tests have proved that it causes a burning of the vegetation surrounding the trees.

(5) Orthodichlorobenzene and kerosene in equal parts, applied as a spray, was too penetrating. It killed both borers and trees. The injury was apparent within a few days after treatment.

(6) Orthodichlorobenzene emulsion was effective, giving practically complete control. Dilutions consisting of equal parts of stock emulsion and water and of one part stock to two parts water were equally effective. These treatments did not appear to injure any of the trees.

Emulsions applied after the borers had penetrated the wood (on May 15) were only partially effective, as only those larvae near the entrance to the galleries at the time of treatment were affected. Five trees each were treated with each solution and the probable total number of borers was 165 in each case, except for the paradichlorobenzene-pine tar oil emulsion, where three trees each were treated and the probable number of borers was 99. The following sprays were used in these tests:

(1) Equal parts of orthodichlorobenzene stock emulsion and water; one part stock emulsion to two parts of water; and one part of stock emulsion to four parts of water.

(2) Similar results were obtained with an emulsion of paradichlorobenzene and pine-tar oil applied in strengths of equal parts of stock emulsion and water and one part of stock emulsion to two parts of water.

It will be noted in Table 1 that in general a high percentage of the borers was killed when the sprays were applied in the early spring before the young larvae had penetrated the wood. At this time they were still present under the bark near their entrance holes, where it was comparatively easy for the chemicals to reach them. On the other hand, after the borers had penetrated the wood only a few were killed which were near the entrances to their galleries at the time of application of the sprays. It appears that after the young larvae have penetrated the wood for a distance of one-fourth inch or more it is difficult for the chemicals to reach them.

TESTS OF 1929. During the spring of 1929 further tests were made with emulsions for the control of the locust borer in infested black-locust trees in the vicinity of Asheville, N. C. Some of the materials that gave the most promising results during the previous season were tested again

TABLE 2. EFFECT OF VARIOUS EMULSIONS ON YOUNG LARVAE BEFORE ENTERING THE WOOD. TESTS OF 1929

Material	Strength	Number of trees treated	Number of borers			Per cent mortality	Effect on—	
			Total	Dead	Alive		Tree[2]	Ground cover[2]
Paradichlorobenzene-pine-tar oil emulsion[1]	1 part	10	175	175	0	100.0	None	
Water	2 parts							
Sodium arsenite	1 lb.	10	134	128	6	95.6	None	Grass and weeds killed
Kerosene emulsion	10 gals.							
Orthodichlorobenzene	1 qt.	10	116	114	2	98.3	None	Slightly burned
Kerosene	1 qt.							
Whale-oil soap	1 lb.							
Water	1½ gals.							
(Stock emulsion)								
Orthodichlorobenzene-kerosene (stock emulsion)	1 part	10	115	114	1	99.1	None	
Water	2 parts							
Orthodichlorobenzene emulsion	1 part	10	93	90	3	96.8	None	Slightly burned
Water	2 parts							
Orthodichlorobenzene emulsion	1 part	10	108	106	2	98.1		
Water	6 parts							

[1]Mixture stains the bark dark. Odor strong after two months.
[2]Where no burning is recorded it is assumed that none occurred.

and dilutions of other emulsions were tried. Most of the work was done with emulsions, as it was believed that they would largely eliminate the danger of any subsequent harmful effects of the poisons upon the trees, would stick well, and would lessen the cost of treatment. In view of the results obtained during 1928, all the tests were confined to the spraying of trees previous to the period during which the young borers enter the wood. These tests were made on trees located in a different plantation from that used during 1928. The site was a relatively poor one for tree growth but favorable for beetle attack. The trees, although of about the same age as those in the 1928 plot, averaged only 3.6 inches d.b.h. and 12 feet in height. In the basal 6-foot sections of 60 trees, 741 active borers were found on April 18, 1929 (the time of application of the sprays), which represented 12 borers per tree. Many of the trees had been attacked repeatedly year after year, so that they appeared to have been riddled by borers.

Preliminary results were obtained on May 14, nearly three weeks after treatment, and they were rechecked on June 20, five weeks later, to note the ultimate effects of the solutions on them. By this time the mortality had increased slightly. The results presented in Table 2 are as of the latter date. The trees were again rechecked during the springs of 1930 and 1931, to note any latent effects of the solutions upon the trees, as well as upon the ground cover of grass and weeds, and these results are given in Table 2.

The spraying experiments of 1929 gave the following results (Table 2):

(1) The use of paradichlorobenzene-pine tar oil emulsion, applied with a brush, to protect infested locust trees from borer injury during the early spring was again successfully demonstrated. However, its use is somewhat objectionable on account of the difficulty of application.

(2) Sodium arsenite-kerosene emulsion was also effective. A kill of 95.6 per cent was obtained, but the solution caused a slight burning of the ground cover surrounding the trees.

(3) Undiluted orthodichlorobenzene-kerosene emulsion gave almost complete control (98.3 per cent). There was, however, a slight burning of the ground cover. A dilution at the rate of one part of stock emulsion to two parts of water was just as effective, a kill of 99.1 per cent of the larvae being obtained, but no burning of the ground cover was noted.

(4) The use of orthodichlorobenzene stock emulsion one part, to water two parts was again proved to be satisfactory, a kill of 96.8 per cent of the borers being obtained. A slight burning of the foliage was noted. Further dilutions of this stock emulsion at the rate of one part to six

parts of water gave a kill of 98.1 per cent of the borers, but no burning of the ground cover occurred.

It will be noted that a high percentage of mortality was obtained with all sprays that were applied to the trees in the early spring before the larvae had entered the wood.

Cost of Application of Most Effective Sprays. From the foregoing tables and discussion it is evident that emulsions of orthodichlorobenzene and paradichlorobenzene-pine tar oil were the safest and most effective. Inasmuch as about one pint of solution is required to treat the entire infested trunk of an average tree (5 inches d.b.h., 16 feet high), and since the orthodichlorobenzene enulsion was diluted by six parts of water, the cost of application of this mixture was about 1.5 cents per tree. By using two parts of water with the paradichlorobenzene-pine tar oil emulsion the cost is about 3 cents per tree. These figures do not include the cost of labor.

It has been repeatedly observed that all trees are not subject to infestation, nor do all parts of the trunks of attacked trees contain borers. Furthermore, the particular place to be treated to kill the tiny borer beneath the bark is easily detected during the early spring. In addition to this, trees are seldom infested up to the time they have reached a diameter of 1 or 2 inches and are much less subject to attack after they have attained a diameter of about 8 inches. Therefore, the bark surface to be treated on any particular tree is apt to be much less than was estimated above, and the tree needs to be protected only during a certain period of its life. These factors should tend to reduce the above cost estimates when the expense of protecting a large number of trees, as in the case of plantations, is being determined.

Conclusions. The most effective time to spray locust trees for the control of the borer is in the early spring, about the time the leaves unfold, while the larvae are still present between the bark and wood. At this time they are readily affected by the spray. Later applications, after the borers have begun to penetrate the wood, are only partially effective and somewhat in inverse proportion to the depth that they have penetrated the stem.

The following sprays are unsatisfactory: (1) Kerosene emulsion was only partially effective; (2) equal parts of orthodichlorobenzene and kerosene proved to be too penetrating, for the spray killed not only all the borers but the tree as well.

The following sprays are satisfactory from the standpoint of control of the borers and do not injure the trees, but they cause a burning of the surrounding vegetation: (1) sodium arsenite-kerosene emulsion; (2)

crude orthodichlorobenzene; (3) orthodichlorobenzene-kerosene stock emulsion; (4) orthodichlorobenzene stock emulsion applied undiluted; (5) orthodichlorobenzene stock emulsion one part to water two parts.

The following emulsions injure neither the trees nor the surrounding vegetation, and result in almost complete control of the borers: (1) Paradichlorobenzene-pine tar oil emulsion (proved to be satisfactory except that it had to be applied with a brush and also that it stained the bark a dark color); (2) orthodichlorobenzene-kerosene emulsion stock solution one part to water two parts; (3) orthodichlorobenzene emulsion stock solution one part to water six parts.

The last two mentioned emulsions are probably the safest, cheapest, and most easily applied of all the sprays that were used in the control of the locust borer during the early spring months before the larvae had penetrated the wood. The cost of application, excluding labor, of the last three mentioned sprays is found to be from 1.5 cents to 3 cents per tree.

Literature Cited

1. Compton, C. C., and Flint, W. P. 1927. A suggestion for controlling the locust borer, *Cyllene robiniae*. Jour. Econ. Ent. 20:295–298.
2. Cotton, E. C. 1906. The insects affecting the black locust and hardy catalpa. Ohio Dept. Agr., Div. Nursery and Orchard Inspection, Bul. 7, 55 p.
3. Craighead, F. C. 1919. Protection from the locust borer. U. S. Dept. Agr. Bul. 787:1–12, illus.
4. Garman, H. 1916. The locust borer and other insect enemies of the black locust. Ky. Agr. Expt. Sta. Bul. 200:99–135.
5. Gillette, C. P. 1907. Insect pests. The Colorado Fruit Grower 2 (April): 3–5.
6. Hopkins, A. D. 1906. Some insects injurious to forests. I. The locust borer. U. S. Dept. Agr. Bur. Ent. Bul. 58:1–16, illus.
7. Hopkins, A. D. 1907. Some insects injurious to forests. III. Additional data on the locust borer. U. S. Dept. Agr. Bur. Ent. Bul. 58:51–40.
8. Houser, J. S. 1908. The more important insects affecting Ohio shade trees. Ohio Agr. Expt. Sta. Bul. 194:169–243, illus.
9. Severin, H. C. 1910. Black locust borers. 7th Ann. Report S. Dak. State Hort. Soc.: 123–124.
10. Washburn, F. L. 1907 and 1908. Some destructive shade tree pests. The locust borer. 12th Report of State Entomologist of Minn.: 91–122.

GRASSHOPPER-CONTROL EXPERIMENTS

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ABSTRACT

Poisoned-bran mash was found to be the most efficient grasshopper control remedy under the existing conditions in northwestern Florida. Several series of experiments were carried out during the years 1926–1930 to determine the value of various attractants in the bait. While the results obtained were inconclusive, they give indications that the attractants incorporated in the bait were of little, if any, value.

While extensive grasshopper-control investigations have been carried out in the middle and western regions of the United States, apparently little work has been done in the southeastern district. One of the problems in northwestern Florida has been to protect tobacco and truck crops from damage by these insects. Under the prevailing conditions it has been found necessary to control the grasshoppers on grassland immediately adjacent to the tilled crops. This has been readily accomplished when the grasshoppers were concentrated on comparatively small areas. Tests with several poisonous dusts and baits showed that baits made with a bran base were the most effective and practical remedy.

The problem finally resolved itself into a determination of the most efficient bait, a subject which has been the cause of much debate among entomologists. These studies were conducted in Gadsden County, Florida, during the years 1926–1930 whenever time and conditions would permit.

PREDOMINATING SPECIES.[1] Infestations in these experiments consisted mainly of *Melanoplus femurrubrum propinquus* McN. and *M. mexicanus* Sauss. Collections made over several years in Gadsden County, Florida, showed that *propinquus* was the much more abundant of the two species. Other hoppers present in less abundance were *Orphulella pelidna* Burm., *Chortophaga viridifasciata* var. *australior* R. & H., *Psinidia fenestralis* Serv., and *Conocephalus fasciatus* DeGeer.

SEASONAL HISTORY NOTES. Observations of *M. femurrubrum propinquus* and *M. mexicanus* indicated that both species are very similar in habits in this region. Infestations appeared to be rather uniform from year to year with few unusual outbreaks.

While the demarcation between broods was not distinct, there appeared to be two well-defined hatchings. Emergence of the spring brood from overwintered eggs was found to be affected quite perceptibly

[1]Determinations by Mr. A. N. Caudell.

by weather conditions but usually commenced during the latter part of March and continued for several weeks. A few scattered nymphs frequently appeared much earlier. Nymphs developed into adults during May and June and usually died shortly after reaching this stage.

The second brood of young grasshoppers usually appeared about the first of July. Adults of the spring brood confined in an outdoor cage deposited eggs between June 21 and July 10 which hatched between July 20 and August 7, the average incubation period being 30.6 days.

Adults of the second brood, together with nymphs of all ages, were usually abundant in the late summer and fall months. A few nymphs have been observed as late as November 25, which may indicate a tendency toward the production of a third brood. It appeared that these invariably succumb during periods of cold weather.

Adults decline in numbers as winter progresses but a few individuals have frequently been found during December and January. It appeared that very few, if any, survive the entire winter.

METHODS. All methods yet devised for determining the relative value of grasshopper baits are subject to certain apparently unavoidable errors. The method finally adopted for use in these experiments was very similar to that advanced by Ford and Larrimer (*1*). While containing the defects common to this type of experiment, it appeared to be the best obtainable under the existing conditions.

Plots of one-fourth acre on infested grassland were treated with the various baits at the rate of 10 pounds, wet weight, per acre, while alternate plots were left untreated to avoid error due to the migration of grasshoppers from one poisoned plot to another. Applications of bait were made between 8 and 9 o'clock in the morning and sweepings were made from the plots after an interval of about 6 hours, before any of the grasshoppers had had time to die from the effects of the poison. The hoppers, confined in screen-wire cages (2 feet by 2 feet) provided with sliding doors to facilitate their introduction, were kept on an open porch and given food. Cages were examined daily and the dead individuals removed and recorded. Experiments were closed at the end of the sixth day. In each case a lot of hoppers obtained from an adjacent unpoisoned area served as a check.

Wheat bran and Paris green mixed in the proportion of 25 to 1 by weight served as the basis of each bait. Cornmeal husk and sawdust were tested as substitutes for bran in several instances but proved to be unsatisfactory. The attractants tested were added to the poisoned bran in the following proportions: To 25 pounds of bran-molasses or syrup, 2 quarts; salt, 1 pound; lemons, 6; nitrobenzene or amyl acetate,

¾ ounce. Sufficient water was added to bring the mash to the proper consistency. All baits were prepared the day previous to the application and allowed to stand over night.

TABLE 1. RESULTS OF GRASSHOPPER-ATTRACTANT EXPERIMENTS

Attractant	Total number of hoppers	Number dying	Number alive	Per cent alive	Per cent control
(Results obtained in 1926)					
Cane syrup and lemons	384	357	27	7.0	91.4
Cane syrup and amyl acetate	518	481	37	7.1	91.2
Nitrobenzene	452	411	41	9.0	88.8
Cane syrup and nitrobenzene	508	450	58	11.4	85.0
Cane syrup	452	383	69	15.2	81.2
Cane syrup, lemons, and salt	523	433	90	17.2	78.7
Lemons	530	429	101	19.0	76.5
Check	469	89	380	81.0	—
(Results obtained in 1927)					
Cane syrup and amyl acetate	912	686	226	24.7	71.5
Nitrobenzene	1020	763	257	25.1	71.0
Cane syrup and lemons	988	703	285	28.8	67.7
Amyl acetate	717	507	210	29.2	66.3
Plain bran mash	890	617	273	30.6	64.7
New Orleans molasses	460	318	142	30.8	64.4
Cane syrup	1082	733	349	32.2	62.8
Check	610	81	529	86.7	—
(Results obtained in 1928)					
Lemons	105	82	23	21.9	71.4
Blackstrap molasses	194	147	47	24.2	68.4
Plain bran mash	98	74	24	24.4	68.1
Cane syrup	204	149	55	26.9	64.9
Amyl acetate	75	53	22	29.3	61.7
Nitrobenzene	103	70	33	32.0	58.2
New Orleans molasses	188	117	71	37.7	50.8
Check	73	17	56	76.7	—
(Results obtained in 1929)					
Blackstrap molasses	578	442	136	23.5	73.8
New Orleans molasses	489	372	117	23.9	73.4
Cane syrup	637	434	202	31.7	64.7
Nitrobenzene	487	324	163	33.4	62.8
Amyl acetate	561	355	206	36.7	59.2
Plain bran mash	486	303	183	37.6	58.2
Lemons	530	315	215	40.5	55.0
Check	430	43	387	90.0	—
(Results obtained in 1930)					
Blackstrap molasses	311	263	48	15.4	82.1
New Orleans molasses	214	178	36	16.8	80.5
Plain bran mash	320	262	58	18.1	79.0
Lemons	379	305	74	19.5	77.4
Nitrobenzene	506	401	105	20.7	76.0
Amyl acetate	388	304	84	21.6	75.0
Cane syrup	282	220	62	21.9	74.6
Check	275	37	238	86.5	—

The species of grasshoppers previously mentioned were present in the different experiments as nymphs of the last three stages and adults, in varying proportions. First and second stage nymphs were not included in the counts.

RESULTS. Conditions permitted the carrying out of one series of experiments in the season of 1928, of two in 1930, of three each in 1926 and 1927, and of four in 1929. Where more than one series was performed in the same season, the results for that season have been combined to form a single series. The normal mortality varied considerably from year to year and for this reason the efficiency of the various baits has been calculated as "per cent control" (*2*).

The most significant feature of the results is the marked inconsistency between the different series. These inconsistencies may perhaps be accounted for by variations in the proportions of species, variations in sex, in age, and in the number in the process of molting. The natural death rate, the movement of hoppers in the field, and other uncontrollable factors doubtless tended also to obscure the true results. It is possible that the natural food on the plots, which was more or less variable in character, influenced the hoppers' food preferences to a very appreciable extent, as has been observed by Morse (*3*).

When the experiments performed in 1927, 1928, 1929, and 1930 are averaged and all baits containing attractants are checked against the plain bran mash in these experiments, the per cent control is not materially different,—68.1 in the case of the attractants and 65.6 in the case of the plain poisoned mash. In the last three series (1928, 1929, and 1930) in which blackstrap molasses was used, the results obtained with this material show a higher average trend than the results obtained with any of the other attractants. The combined results in these three experiments show a 75 per cent control for the blackstrap molasses compared with 68.3 per cent in the case of the plain bran mash, a difference of doubtful significance when the erratic trend of the data as a whole are considered.

While these results are inconclusive, they give indications that the various attractants used were of little, if any, value. From the practical control standpoint it is evident that plain poisoned-bran mash is an excellent remedy when properly applied.

LITERATURE CITED

1. FORD, A. L., and LARRIMER, W. H. 1921. Some Factors Influencing the Efficiency of Grasshopper Baits. Jour. Econ. Ent. 14:292–299.
2. ABBOTT, W. S. 1925. A Method of Computing the Effectiveness of an Insecticide. Jour. Econ. Ent. 18:265–267.
3. MORSE, ALBERT P. 1930. Grasshopper vs. Salt. Jour. Econ. Ent. 23:465.

Scientific Notes

***Icerya purchasi* in Porto Rico.** Since October 1931 a species of coccid has been observed on the Australian pine (*Casuarina equisetifolia?*), where used as an ornamental in San Juan. The writer was unable to obtain a determination of the species until recently, when Mr. C. E. Pemberton of the Hawaiian Sugar Planters' Association identified it as the cottony-cushion scale (*Icerya purchasi*). On the host mentioned the insect has appeared in great numbers. Where very abundant the trees have been definitely injured, and in some cases have been killed. Two species of ants have been found on the same plant; but whether in association with the scale, has not been ascertained. Partial control has been achieved by the application of water from a garden hose, relatively low pressure probably preventing better results. A gardener who is a good observer informed me that he had noted a bird locally known as "reinita," apparently feeding upon the coccid. Up to the present the casuarina has been practically free of insect enemies in Porto Rico. In all probability it bids fair to become an important pest of this tree, the most rapidly growing one on the island, a potential source of lumber, and of considerable value as a windbreak and ornamental. This note pertains only to the occurrence of *Icerya purchasi* on the island of San Juan, and not to other portions of the city, or Porto Rico.

WM. A. HOFFMAN,
School of Tropical Medicine, San Juan, P. R.

A Second Report on the Efficiency of the Air-Blast Type of Sprayer.—Since our first report on the efficiency of the air-blast type of sprayer for applying insecticides to dormant peach trees (Jour. Econ. Ent., October, 1930), an opportunity has been presented to test that machine for applying sprays to peach trees in foliage. This test was conducted on a large block of Elberta peach trees which was divided into two plats. The air-blast type of sprayer was used for spraying the trees in one plat and the ordinary power sprayer was used for spraying the trees in the other plat. Both plats received the same materials on April 11, May 15, and June 26, 1931, lead arsenate being used for curculio control and sulphur and zinc sulphate for disease control.

Record trees were selected in each plat from which 5,347 peaches were cut open at harvest to determine the results. The curculio infestation was so light in 1931 that the data on the control of that insect were of no significance; however, 16 per cent of the fruit from the plat sprayed with the air-blast type of sprayer developed scab whereas not a scabby peach was found in the plat sprayed with the ordinary spray outfit. Scab is easily controlled by the sulphur sprays and its presence is evidence that the fruit was not thoroughly covered with the material. If the air-blast type of sprayer failed to deliver the fungicide through the foliage to some of the fruit, we can draw the same conclusion for the insecticide. There was 21.7 per cent more sound fruit in the plat sprayed with the ordinary power spray outfit than in the plat sprayed with the air-blast type of sprayer.

OLIVER I. SNAPP and J. R. THOMSON, *U. S. Peach Insect Laboratory, Fort Valley, Georgia*

A Second Report on the Oriental Fruit Moth Infestation in the Georgia Peach Belt.—During the harvesting season of 1931 all of the peaches from many trees scattered throughout three large orchards in the vicinity of Fort Valley were cut open

to determine which contained oriental fruit moth larvae, or had been damaged by the insect, in order to obtain accurate data on the degree of infestation. This insect has never been of much economic importance in the central Georgia peach belt on account of the absence of suitable food after midsummer, which causes a heavy mortality of larvae that would otherwise hibernate; however, there has been considerable speculation as to the extent of infestation in peaches harvested in that district, and at times growers have held the oriental fruit moth responsible for damage caused by the plum curculio. The first report on the degree of oriental fruit moth infestation in the Georgia peach belt was published as a scientific note in the Journal of Economic Entomology, Vol. 23, No. 6 (December, 1930).

The three orchards used for the 1931 records were of the Elberta variety. That is the last peach to mature in the district, and it is therefore subjected to the heaviest infestation of the oriental fruit moth. No control measures whatever for the oriental fruit moth had been practiced in the three orchards, and on account of the late harvesting season, the fruit was not picked until several weeks after the larvae had ceased to work in the hardened peach twigs.

Of 38,196 peaches cut open and examined from trees in orchard No. 1, which was apparently the most heavily infested orchard in the locality, only 202, or 0.5 per cent, were found to be infested by the oriental fruit moth. Of 5,347 peaches cut open and examined from trees in orchard No. 2, only 6, or 0.1 per cent, were infested by the insect. Not a single peach infested by the oriental fruit moth was found in the 3,278 peaches cut open and examined from trees in orchard No. 3.

OLIVER I. SNAPP and J. R. THOMSON, *U. S. Peach Insect Laboratory, Fort Valley, Ga.*

The Black Onion fly, *Tritoxa flexa* (Wiedemann). Larvae of this interesting American insect were discovered in growing chives at Santa Barbara, February 4, 1932 by Eugene S. Kellogg, Agricultural Commissioner of Santa Barbara County. Specimens forwarded to the writer were first believed to be those of the common European onion maggot, *Hylemyia antiqua* (Meigen), which is widely distributed throughout the country. However, they appeared somewhat different and were placed in a rearing cage, which in a few weeks yielded a very interesting ortalid fly of a striking black color with three arcuate, narrow, white bands on each, otherwise opaque black wing. Fortunately some of the maggots were preserved in alcohol. In general appearances they resemble those of the onion maggot, but Chittenden[1] calls attention to the following differences between the two: "It (larva of black onion fly) is longer and more slender and may readily be distinguished by the anal extremity being squarely, instead of obliquely, truncate and by lacking the fringe of marginal tubercles, so prominent in the species of *Hylemyia*."

Adults were submitted to F. R. Cole, who identified them as the above and stated that this was probably the first record of the insect in the West.

A survey of existing literature[2] shows that the fly was originally described by C. R. W. Wiedemann in 1830 as *Trypeta flexa*. In 1856 Francis Walker described the same species as *Trypeta arcuata*.

Henry Shimer, in 1865, first recorded it as injurious to onions in Illinois and again referred to it in 1870 as follows: "has been heard of in one or two circumscribed localities in the West, and even there does comparatively but little damage."

[1]Chittenden, F. H., Can. Entom., Vol. 59, pp. 1–4, 1927.

[2]See Chittenden, loc. cit. for bibliography.

The work of the insect is recorded as similar to that of the onion maggot, but apparently not nearly as destructive, since it is rarely referred to in the literature of economic entomology. The larvae have been reared mostly from onions and chives taken from the field. Whether it is actually a primary pest on sound plants or a scavenger, following decay, does not appear to have been definitely determined. The infested chives which I received were in a decidedly unhealthy condition, due either directly to the attacks of the larvae or to decay.

E. O. Essig, *Berkeley, Calif.*

A Note on the Use of Trichogramma Parasites in Orchards. The practicability of using Trichogramma egg parasites for the control of any of the host insects is primarily dependent on the cost of producing and liberating a sufficient quantity of the parasites to bring about commercial control, or in some cases a degree of partial control which is of distinct economic advantage. It has been assumed by some investigators that it is necessary to liberate many thousands of Trichogrammas in a single tree in order to obtain practical results in the control of such pests as the codling moth or the Oriental fruit moth, but there is evidence now available to the effect that even a few hundred parasites per tree liberated at opportune times may give rather striking results. In one instance the liberation of an average of only 165 parasites per tree in an apple orchard over a period of several weeks was followed by approximately 43 per cent of parasitism of codling moth eggs in a section where the natural parasitism was absent or negligible. Mr. Schread (Jour. Econ. Ent., 25, p. 372) has recorded an instance where the average liberation of less than 500 Trichogrammas per tree was followed by parasitism of approximately 54 per cent of the eggs of the Oriental peach moth. Leaving out of consideration the fact that the effects of the liberation were observed well beyond the limits of a block of 49 trees centering in the tree in which 20,000 Trichogrammas were liberated, this block may be considered as averaging 408 parasites liberated per tree and the subsequent recorded parasitism as averaging 50.7 per cent. On the other hand, Messrs. Allen and Warren in Southern New Jersey have recorded results of comparatively little commercial importance in the control of the Oriental fruit moth from liberations averaging approximately 400 adults per tree (Jour. Econ. Ent., 25, p. 380). The cost of producing and liberating this number of parasites these authors estimated at not less than 18 cents per tree. In determining the practicability of Trichogramma liberations, the present commercial value of the parasites and the cost of newly devised methods for liberating them should be considered. For 18 cents per tree, from 900 to 1250 parasites may be liberated at present costs, or from two and one-fourth to three times as many as were used in the experiments referred to. These estimates apply to parasites purchased commercially for one thousand trees in the first instance and for four thousand trees in the second. For less than one thousand trees the costs for the numbers mentioned would be proportionately greater or, in other words, a proportionately smaller number could be distributed for a cost of 18 cents per tree.

A. W. Morrill

A newly Observed Insect Pest in Hudson Valley Pear Orchards.—During the latter part of May, 1931, an orchard of mature Bartlett pear trees near Plattekill, Ulster County, N. Y., exhibited many injured leaves on growing terminal shoots. Similar injury, tho less extensive, was found at other points in the Hudson valley, viz.: Clintondale, Red Hook and Hudson.

Injury is confined to the leaves and appears to be most prominent on trees that are making rapid growth. The edges of the affected leaves are tightly rolled parallel to the midrib and when first injured bear many small, red, gall-like swellings, but later these leaves turn black. The older infested leaves showed exit holes and dropped to the ground at the slightest disturbance. Sometimes as many as thirty larvae were found in an infested leaf. On June 8 hundreds of small midges were observed ovipositing on the soft-wooded terminal shoots. Egg-laying continued until the middle of August, but the eggs were numerous during June and early July. The eggs are reddish yellow in color and ellipsoidal. A bright red eye spot appears in the embryo shortly after the egg is laid and persists for a time in the young larva. The eggs hatched in four to six days, and the small, orange-colored larvae were observed living among the leaf hairs at the edges of the newly formed foliage. Their color changed after a short time to a pure white. The length of the larval stage in the leaves was about 18 days. In a few instances the larvae pupated in the leaves, but usually the maggots dropped to the ground before pupating. Specimens of the insect were sent for identification to Dr. H. F. Barnes, Rothamsted Experiment Station, Harpenden, England, who writes that he believes them to be *Dasyneura pyri* Bouché, known as the pear leaf-curling midge. This is an European insect reported to be very destructive, especially in young pear orchards.

Several interesting parasites and predators attacking the midge were found. Some were small Hymenoptera which were active during the early part of the season ovipositing in the midge larvae, while larger species belonging to this same group were ovipositing in the curled leaves. A small predaceous hemipteron, appearing in numbers, attacked the midge in all the stages of the latter. This bug oviposited in the leaf petioles, and both adults and nymphs were active most of the season. A species of red mite was found attached to an adult midge. Parasite cages were used during the summer and by this means the various parasitic species were obtained. Since many terminal branches of the infested pear trees were stripped of leaves due to injury by the midge, even tho the latter was heavily beset by parasites and predators, it would appear that the pest is not easily held in check by these enemies.

Tho the larvae are protected while in the leaves, the eggs and adults can be reached by sprays and dusts. Sprays containing lime-sulfur 1 to 40 killed some of the eggs, while a dilution of 1 to 8 killed all the eggs it touched. At present it is not known whether the midges appear sufficiently early in the spring to enable the grower to use the latter dilution for the control of the leaf-curling midge. It is difficult to wet all the eggs with lime-sulfur sprays because the eggs are among the leaf hairs which prevent the spreading of the liquid.

F. G. MUNDINGER, *Hudson Valley Laboratory of New York State Agricultural Experiment Station, Poughkeepsie, N. Y.*

Reactions of Sulphuric Acid on Sodium Cyanide. The sources of hydrocyanic acid gas for fumigation purposes have undergone decided changes in the last ten years. Hydrocyanic acid is available in the form of a liquid or the liquid absorbed in an inert carrier such as kieselguhr (Zyklon) or fiber discs (Discoids). For other types of work, hydrocyanic acid gas may be obtained from calcium cyanide, which gives off its gas upon exposure to the air without requiring decomposition by acids. These new materials have very largely rendered obsolete the generation of hydrocyanic acid gas from sodium cyanide and dilute sulphuric acid.

Occasionally some laboratory workers, in carrying out tests, have need for small quantities of hydrocyanic acid gas. Such small quantities are often obtained from calcium cyanide, but some workers generate it from sodium cyanide and sulphuric acid in flasks. Certain observations have indicated that these workers do not always realize that the action of concentrated sulphuric acid upon sodium cyanide is quite different from the action of dilute sulphuric acid. Although various bulletins and text books on entomology, in giving directions for the production of hydrocyanic acid gas from sodium cyanide, give the required proportions of sulphuric acid and water, only a few mention the fact that if concentrated sulphuric acid is used, little or no hydrocyanic acid gas is evolved. Failure of certain workers to recognize this fact has produced surprising results from the use of what they thought was hydrocyanic acid gas.

The reactions of sulphuric acid upon cyanides have been fully pointed out by Wade and Panting (Journal Chem. Soc., Vol. 73, pt. 1, pp. 255–258, 1898). They found that when dilute sulphuric acid acts upon an alkali cyanide, hydrocyanic acid and water vapor are given off. Increasing the concentration of the sulphuric acid decreases the amount of water vapor until with a mixture of equal parts of sulphuric acid and water very little water vapor is evolved. Upon further increasing the concentration of the sulphuric acid, a certain amount of carbon monoxide is produced; the quantity of carbon monoxide increases as the concentration of the sulphuric acid is increased, while the amount of hydrocyanic acid gas given off decreases. When ordinary concentrated sulphuric acid acts upon sodium cyanide, if the mixture is not too hot, nearly pure carbon monoxide gas is evolved in almost theoretical amounts. This reaction is due to the hydrocyanic acid being changed to ammonia and formic acid. The ammonia combines with the sulphuric acid to form ammonium sulphate, while the formic acid is dehydrated by the concentrated sulphuric acid, forming carbon monoxide. (Kjeldahl's method for the determination of nitrogen.) If, however, the mixture becomes quite hot, due to the reactions resulting from the too rapid addition of the sulphuric acid to the sodium cyanide, the sulphuric acid is reduced and the gases given off are sulphur dioxide and carbon dioxide.

In brief, when sulphuric acid reacts with sodium cyanide several gases may be evolved, depending upon the concentration of the acid, the proportions of acid to cyanide and the conditions of the experiment. The gases may be hydrocyanic acid gas obtained from properly diluted acid; mixtures of hydrocyanic acid and carbon monoxide from more concentrated acid; nearly pure carbon monoxide from ordinary concentrated sulphuric acid; mixtures of carbon monoxide, carbon dioxide and sulphur dioxide if the temperature runs up during the reaction, and at high temperatures a mixture of carbon dioxide and sulphur dioxide. If the quantity of sulphuric acid is so small that it does not cover the cyanide some hydrocyanic acid may be evolved along with the other gases.

It is not surprising that workers who use strong sulphuric acid and sodium cyanide as a source of hydrocyanic acid gas obtain erratic results, considered either from the point of view of insect kill or chemical analysis for hydrocyanic acid gas.

WILLIAM MOORE, *American Cyanamid Sales Co., New York City*

The Trend in Pest Control Inventions in the United States. During 1931 the United States Patent Office issued 51,766 patents and 395 reissues. The writer abstracted 537 of these in the monthly "Review of United States Patents Relating to Pest Control" as being of interest to chemists, entomologists, bacteriologists,

public health officials, plant pathologists, agronomists, horticulturists, and farmers interested in the problems of combating economically harmful bacteria, fungi, weeds, protozoa, nematodes, insects and rodents.

An examination of these patents on pest control shows that the American inventor in this field is mechanically rather than chemically minded. Roughly, 390 out of 537 patents, or 73 per cent, relate to mechanical devices and 27 per cent to chemical products or processes.

A table of the principal classes of these patents of interest to entomologists is as follows:

Apparatus	Number of patents issued
Fly and mosquito screens	89
Fumigating apparatus	35
Spraying apparatus	30
Dusting apparatus	11
Insect traps and poison-bait containers	26
Beekeeping devices	12
Fruit-washing apparatus	3
Chemical Products and Processes	
Arsenicals (inorganic)	8
Mercurials (mostly for use as seed disinfectants)	13
Oil emulsions	8
Fumigants	10
Synthetic organic insecticides	6
Fungicides	9

Other patents were issued for 55 rodent and game traps, 37 sterilizers and pasteurizers, 43 weeders and devices for applying poison to the roots of weeds, 34 bactericides, disinfectants and deodorizers, 9 organic arsenicals, 14 disinfecting devices, 6 apparatus for wood preservation, 3 tree surgery processes, 3 animal greasers, 1 fly swatter, 1 field insect catcher, 2 machines for knocking boll weevils from cotton plants, 3 mothproof bags, 1 flypaper support, 2 tree bands, etc.

The writer regrets that, as shown by the figures above, relatively so little attention is being devoted to the development of new chemical compounds and mixtures for insect control. Surely our present window and door screens are not so inefficient as to make necessary the large amount of work by inventors revealed by the issuance of 89 patents on the subject in a twelve months' period many years after the first fly screen was used in the United States. What is needed is the invention of many new insecticides and fungicides to help the entomologist and the plant pathologist in their battles with an increasing variety and number of insect, fungus and bacterial pests.

Sixteen United States patents on chemical products and processes were issued to foreign inventors. Included among these are patents on certain new synthetic organic compounds which appear likely to become valuable insecticides. Is the American chemical inventor content to neglect this field, while the rights to the latest and most promising developments in pest control pass into the hands of foreign manufacturers of chemical products?

R. C. ROARK, *Principal Chemist Insecticide Div., Bur. Chemistry and Soils, Washington, D. C.*

Carbon Disulphide Emulsion to Control Gladiolus Thrips,[1] ***Taeniothrips gladioli*** **M. & S.**—The series of experiments tabulated below were undertaken in a search for a cheap, effective, and safe method for treating stored gladiolus corms infested with *Taeniothrips gladioli*, M. & S. The method of treatment was essentially as follows, varying numbers of dormant corms, depending somewhat upon the size, were placed in muslin sacks and immersed for the indicated periods in the various solutions. At the expiration of the period of immersion, the corms were removed, dried, examined for the thrips and possible injury, and then planted in the greenhouse for observation of the effect of treatments on growth. It was possible to determine by their appearance the injured corms.

Treatment	Length of treatment	Effect on thrips	Growth in greenhouses
Nicotine sulphate and soap, 4 lbs. in 100 gals.:			
1–800	24 hours	All dead	Normal
1–400	24 hours	All dead	Normal
Nicotine sulphate, 1–800+Penetrol, 1–200	24 hours	All dead	Normal
Red Arrow, 1–2000	24 hours	All dead	Normal
Yarmor Pine Oil, 1–40 (emulsified with potash castor oil soap)	4 hours	All dead	Dead
	6 hours	All dead	Dead
50% wormseed oil emulsion 3⅓ cc. to 100 cc. water	14 hours	All dead	Dead
50% miscible carbon disulphide, 1–1000	15 min.	All dead	Growth stimulated, all alive
	30 min.	All dead	Growth stimulated, all alive
	1 hour	All dead	Growth stimulated, all alive
	2 hours	All dead	Growth stimulated, all alive
	3 hours	All dead	Growth stimulated, all alive
	4 hours	All dead	Growth stimulated, all alive
	5 hours	All dead	Growth stimulated, all alive

It must be understood that our plants have not flowered to date and we have on means of judging the final results.

EUGENIA I. MCDANIEL,
Associate Professor of Entomology, Michigan State College

ENTOMOLOGY AT THE FOURTH CONGRESS OF THE INTERNATIONAL SOCIETY OF SUGAR CANE TECHNOLOGISTS IN PORTO RICO

The fourth Congress of the International Society of Sugar Cane Technologists was held in San Juan, Porto Rico, March 1 to 16, 1932. The Section on Insect Pests of Sugar cane was well attended. Among those present were the Chairman, C. E. Pemberton, Hawaiian Sugar Planters' Experiment Station; J. G. Myers, Imperial Institute of Entomology, Trinidad, B. W. I.; H. E. Box of Antigua, B. W. I.; and from Porto Rico: M. D. Leonard, G. N. Wolcott and F. Sein of the Insular Experiment Station; Julio Garcia Diaz and Rachel R. Dexter of the University of Porto

[1]Journal article No. 102 (n. s.) from the Mich. Agr. Exp. Sta.

Rico; Stuart T. Danforth of the College of Agriculture at Mayaguez; Wm. A. Hoffman of the School of Tropical Medicine; L. A. Catoni of the Insular Plant Quarantine Service; Richard Faxon and A. S. Mills of the U. S. Plant Quarantine and Control Administration and several visitors.

Twenty papers on various phases of sugar cane entomology from Java, Hawaii, Philippines, Louisiana, Cuba, Porto Rico, Antigua, Barbados and Peru were presented at four separate sessions. One session was almost entirely devoted to a discussion of the moth borer, *Diatraea saccharalis* Fab., giving special emphasis to factors affecting its abundance and to methods of measuring the degree of infestation. A committee was appointed to attempt to standardize the latter. Another session was given to the general subject of biological control of sugar cane insects and to the preparation of a list of the sugar cane insects of the world and their natural enemies. A committee was appointed for the fulfillment of this project. Of particular interest was a paper on the food habits of an imported toad, *Bufo marinus* L., in Porto Rican cane fields. At the third session three important papers were read on the utilization of the egg-parasite, *Trichogramma minutum* Riley, by means of mass production for the control of the sugar cane moth borers. An illuminating inquiry into the merits of this method followed. The final session was held jointly with the Section on Diseases of Sugar Cane. This included a discussion of the relation of insects to certain sugar cane diseases, chiefly mosaic and root troubles. At this session was presented the report of the Committee on Protective Sugar Cane Quarantine which included a special discussion of a cane butterfly, *Calisto pulchella* Lathy, peculiar to Santo Domingo and Haiti.

The technical sessions were followed by an extended tour of the Island to visit the principal Centrals where the more important sugar cane insects were observed in the field.

C. E. PEMBERTON, *Entomologist, Hawaiian Sugar Planters' Association* and
M. D. LEONARD, *Entomologist, Insular Experiment Station, Porto Rico*

ADDITION OF COLOR TO AGRICULTURAL INSECTICIDES

The following is a letter sent to official entomologists by the Manufacturing Chemists' Association of Washington, D. C.

The following bills now pending in the Federal Congress require the discoloration of poisons, including insecticides and fungicides, and are understood to have been introduced at the request of the Southeastern Millers Association of Nashville, Tennessee, originating from cases arising in the South where calcium arsenate was accidentally mixed with flour:

H. R. 371—Sam D. McReynolds of Tennessee—To Require the Discoloration of Poisons which Resemble Commonly Used Foodstuffs.

H. R. 5120—Clarence Cannon of Missouri—To Require the Discoloration of Poisons which Resemble Commonly Used Foodstuffs.

H. R. 8639—J. W. Byrns of Tennessee—To Prevent the Sale or Transportation in Interstate and Foreign Commerce of Commonly Used Poisons Resembling in Color Flour, Meal, or Other Similar Ground Cereal.

H. R. 10584—J. W. Byrns of Tennessee—To Prevent the Sale or Transportation in Interstate and Foreign Commerce of Certain Commonly Used Poisons.

Senate 1229—Cordell Hull of Tennessee—To Require the Discoloration of Poisons which Resemble Commonly Used Foodstuffs.

When this situation was brought to our attention, the Insecticide and Fungicide Committee of the M. C. A., in accordance with the policy of our Association to give careful consideration to matters relating to public welfare, instituted a laboratory investigation into the possibilities of dyeing, coloring, or adding pigments to calcium arsenate and lead arsenate.

Quite aside from the cost of coloring arsenates, which, for the laboratory tests, ran from two-tenths of a cent to two cents per pound for the color alone, comparatively little information was available on the effect or hazard, if any, of colored insecticides and fungicides on cotton, truck crops and fruit trees, and it was believed that practical field tests should be conducted by entomologists in order to secure data and expert advice on the feasibility of this proposal.

Arrangements were completed with the U. S. Department of Agriculture to conduct field crop tests through the experiment stations in the following states: Louisiana, Texas, South Carolina, Maryland, Massachusetts, North Carolina, Washington and Arkansas, in order to collect data on the effects of colored arsenates on a variety of crops, with check tests against uncolored arsenates.

Supplementing the arrangements through the Department of Agriculture, steps are now being taken to have additional field tests run in various State Experiment Stations.

Realizing that the farmer has far more at stake than either the miller or the chemical manufacturer, we desire any suggestions or criticisms or such opinions as you may care to offer in regard to the use and effects of colored arsenates. In this connection, the state of South Carolina has recently passed a law requiring the addition of color to calcium arsenate, lead arsenate and other insecticides and fungicides which are white in their natural state. This law is effective on January 1, 1933.

Any suggestions that you care to offer should be sent to the following address: Manufacturing Chemists' Association, 608 Woodward Building, Washington, D. C.

WARREN N. WATSON,
Secretary

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

JUNE, 1932

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.00 per page. There is a charge of $3.00 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptance illustrations. Photo-engravings may be obtained by authors at cost.

Separates or reprints, if ordered, when the manuscript is forwarded, will be supplied to authors at the rates given below. Note that the number of pages in a reprint may be affected somewhat by the make-up, and that part of a page is charged as a full page. Carriage charges extra in all cases. Shipment by parcel post, express or freight as directed.

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A. A. A. S. Winter meetings: 1932-33 Atlantic City; 1933-34 Boston; 1934-35 Pittsburgh; Summer meetings: 1932 Syracuse, 1933 Chicago, 1934 San Francisco.

The listing by the Editorial Committee of the American Library Association of Howard's "The Insect Menace" as one of the fifty "notable" books of 1931 is a recognition of the widespread effects of insects upon human welfare as well as a richly merited tribute to an admirable presentation of a difficult and necessarily somewhat technical subject. The title amply justifies the subject matter and, while apparently sensational, is really a concise message addressed not only to the general reader, but to keen entomological students throughout the world. It does more than simply hold interest. It presents facts in such a way as to command the attention of all interested in human welfare.

A protest has been filed with the editor relative to a recently published paper. The claim, hardly justified by the facts, was that the article told nothing, since there was very little clue to the identity of the material used in the experimental work. New discoveries necessarily deal with relatively unknown materials and, in some cases at least, it is impossible to give even an approximate chemical composition. This is particularly true of organic substances. The JOURNAL is primarily for the publication of facts for the information of its readers. It is hardly justified in publishing extended data on unknown materials, though preliminary statements of observations in regard to such may well come within its province. It is not easy to draw a sharp line between the admissible and inadmissible, and yet we believe the principles enunciated above will meet with general approval. It is obvious, however, that each individual case must be judged by itself, and, it is perhaps well to admit, that editoral discretion is not necessarily infallible.

Reviews

Fundamentals of Insect Life by C. L. METCALF and W. P. FLINT, pages I–XI, 1–581, 315 text illustrations, McGraw-Hill Book Company, Inc., New York and London, 1932.

A comprehensive knowledge of insects includes more than the ability to recognize the numerous species coming to notice. This volume, in addition to a general account of the economic relation of insects to man, a discussion of insect structure and relations, brief descriptions of the more important groups, also gives an insight into the place insects occupy in the animal kingdom, and an idea of the way they react to their environment. The authors have succeeded in presenting a very readable, comprehensive account of what they correctly term the Fundamentals of Insect Life. One is constantly reminded that we are dealing with a group of living organisms which have numerous important relations to other existing forms of life. The actuating motive is well expressed in the dedication of the volume "To that group of citizens the world over who believe that life may be inspiring wherever found, and however humbly expressed, that human living may be enriched by the study of nature, and that no culture is complete which ignores the many other expressions of creation besides man." The authors have gone far toward the realization of this aim.

The book is based largely upon an earlier, larger volume, "Destructive and Useful Insects," but with the dominating economic aspect of that work largely eliminated and with the addition of new matter. There are, as in the earlier book, an excellent summary of the economic status of insects, a comprehensive discussion of the morphology, anatomy and physiology of insects, an excellent account of the development and metamorphosis of the group, a chapter on the place of insects in the animal kingdom, brief descriptive accounts of the important orders and families of insects, chapters on insect control and two devoted to the biology and ecology of insects, with especial reference to the living environment and the physicochemical environment.

The subject matter gives a comprehensive view of insect life. The text is admirably adapted to instructional requirements. The authors have utilized, as in the earlier volume, a number of grouped illustrations showing typical variations in habits, structures, and the like. The diagram showing the relative number of known species in different groups, the one illustrating the cycles of matter, and that depicting the effect of temperatures upon various insects are all highly desirable aids to instruction. There is a well selected, classified bibliography.

Entomology is a growing science. The literature is vast and widely scattered. The authors in bringing together this digest have shown excellent judgment in the selection of material and have produced a work which is not only attractive, but has a wide range of usefulness for the numerous students of natural history.

E. P. FELT

Current News Notes

Mr. R. Glendenning, Entomological Branch, was re-elected Honorary Secretary-Treasurer, of the Entomological Society of British Columbia, at its 31st annual meeting held in Vancouver on March 5.

Mr. W. A. Ross, Entomological Branch, attended the National Codling Moth and Oriental Fruit Moth Conference, and the North-central States Entomologists' Annual Meeting, held at Wooster, Ohio, March 2–4.

Mr. R. E. Balch, Entomological Branch, of the Fredericton laboratory, N. B., reports that work is going forward on the study of *Dreyfusia piceae* and its relation to balsam gout.

Arthur Gibson, Dominion Entomologist of Canada visited Montreal on May 4 and 5, and while there had interviews with various officials regarding entomological work now in progress or to be incepted.

Mr. G. H. Hammond, Entomological Branch, left Ottawa early in May for Apple Hill, Ont., where he is establishing a field station for the study of white grubs and their control.

For several days in mid-March and early April, Mr. R. P. Gorham, Entomological Branch, was in St. John, N. B., assisting the officers of the Division of Foreign Pests Suppression in plant inspection work.

The Quebec Society for the Protection of Plants held its annual meeting at Macdonald College, Que., April 20 to 24. Messrs. H. G. Crawford, A. G. Dustan, J. J. deGryse and J. B. Maltais of the Entomological Branch staff were present at the meeting.

W. D. Bedard, Bureau of Entomology, left Coeur d'Alene, Idaho, on April 27 for Sullivan Lake, Kaniksu National Forest, where the initial stages of his seasonal work on the biology of the Douglas fir beetle and mountain pine beetle will be started.

S. E. Crumb and Joseph Wilcox, of the Division of Truck Crop and Garden Insects, Puyallup, Wash., attended a conference with the station entomologists at Corvallis, Oregon, on April 16, in connection with investigations of the red-berry mite and the work on earwig parasites.

Mr. Geo. R. Hopping, Entomological Branch, at the field station at Vancouver, B. C., is studying Ambrosia beetles, sawflies and bark maggots attacking hemlock. In connection with hemlock sawflies, he is making arrangements to secure a species of parasite from Mr. G. Takagi, a forest entomologist in Japan.

Charles E. Smith, of the Baton Rouge, La., Laboratory, Bureau of Entomology, attended the Sixteenth Annual Conference of the South Central States Association of Food, Feed, Drug, and Health Officials, held in Birmingham, Ala., April 27 to 29, and participated in the discussion on spray residues on fruits and vegetables.

On March 28 entomologists of the Bureau of Entomology met with specialists of the Bureau of Animal Industry and of the Forest Service, members of the Public Health Service, and members of the Del-Mar-Va Association to discuss ways and means of eliminating the mosquito nuisance from the Delaware-Maryland Peninsula.

Dr. J. M. Swaine, Entomological Branch, was invited by the Faculty of the Forestry School in Syracuse, N. Y., to deliver a series of lectures on forest entomology to the graduate and undergraduate students. These lectures were given on April 13, and great interest in the subject was evinced by the audiences.

Mr. S. W. Bromley has resigned from the staff of the Bartlett Tree Research Laboratories, Stamford, Conn., to accept a position at the Texas Agricultural Experiment Station at College Station. He will be engaged in a special project on the biology of the cotton bollworm under the direction of Dr. F. L. Thomas, Chief of the Division of Entomology.

K. A. Salmon, of the Bureau of Entomology bark beetle control project, Berkeley, Calif., left on April 25 for the Modoc National Forest to continue the experimental work on the Devil's Garden area. He was accompanied on this trip by Albert Wagner and by Field Assistants Johnson, Bacon, Plair, and Wohletz.

H. A. Jaynes, of Cereal and Forage Insect Investigations, Bureau of Entomology, sailed on March 5 from New York for Salaverry, Peru, reaching his official station, Trujillo, Peru, on March 22. He spent the last week in March visiting territory surrounding Trujillo, and made arrangements for collecting parasites of the sugarcane moth borer (*Diatraea saccharalis* Fab.).

Mr. K. E. Stewart, Entomological Branch, at the Indian Head Laboratory, Sask., is working on an investigation of spruce mites. The seasonal history and habits of the mites and the effect of relative humidity on their development, are being worked out, as well as methods of control, including the development of a suitable spray.

On March 22 to 26 M. P. Jones, Bureau of Entomology, of the Insect Pest Survey attended the spray service school at Ithaca, N. Y., where he gave a report of other conferences he had attended during the past winter. Mr. Jones discussed the spray materials that would be used in other regions and the methods of disseminating information.

On February 1 the entomological laboratory of the U. S. Bureau at Yokohama, Japan, was transferred from 223-bluff, Nakamura to No. 21 Yamaskita-cho. This transfer, which provides several advantages, was made in order to get quarters with sufficient space to accommodate the office and laboratory needs of both the Oriental Fruit Moth work, with G. J. Haeussler in charge, and the Japanese and Asiatic Beetle work, L. B. Parker in charge.

Mr. Arthur Gibson, Dominion Entomologist of Canada, sailed from St. John, N. B. on January 16, for England, on a special mission for the Department. He returned to Ottawa on February 21. In England, Mr. Gibson had interviews with the High Commissioner for Canada and other officials of Canada House, as well as representatives of the Ministry of Agriculture. He also visited certain research stations near London, notably the Rothamsted Experimental Station and the Plant Pathological Laboratory, at Harpenden.

P. N. Annand, Bureau of Entomology, of the sugar beet insect investigations, accompanied by R. L. Piemeisel, of the Bureau of Plant Industry, left Twin Falls, Idaho, on April 14 for an examination of the desert areas in eastern and western Utah, with W. A. Shands, Grand Junction, Colo., and E. W. Davis, Salt Lake City, Utah. Particular attention was paid to host plant associations with the idea in

mind of determining the feasibility of control of the beet leafhopper from the standpoint of range management.

The Ninth Rocky Mountain Conference of Entomologists will be held in Pingree Park, Colorado, August 15 to 20 inclusive. The Agricultural College Forestry Lodge will again be made headquarters and the plans so made that the entire family can enjoy the occasion. Anyone desiring additional information should write the Secretary, George M. List, Fort Collins, Colorado.

Mr. C. R. Twinn, Entomological Branch, accompanied by Mr. Frank Herman of the Division of Chemistry, Experimental Farm, Ottawa, spent from Jan. 25 to Feb. 3, in Toronto, carrying out a series of fumigation experiments with ethylene oxide-carbon dioxide and ethylene dichloride-carbon tetrachloride on several species of household and stored product insects, in the fumigation vaults of Langleys Ltd. The experiments proved that both gases are very efficient fumigants. The former, particularly, is easy of application, safe to use, has marked penetrating qualities and is exceedingly toxic to insects.

Mr. Arthur Kelsall, Entomological Branch, reports that work is being continued on fly poisons, using fruit flies. The relative toxicity values of 45 materials have been tested and of these some of the organic poisons have proved to be exceedingly toxic. Apple maggot flies are also being used in the poison tests. It is expected that the results from these studies will greatly facilitate field work to be carried on later. In addition, extensive chemical investigations are being proceeded with in connection with the development of insecticides and fungicides.

H. H. Stage and C. M. Gjullin, engaged in mosquito investigations at Portland, Oregon, attended meetings of the Mosquito Control and Elimination Committee, on April 7 and 18. They made a trip to Seattle, Wash., and Bainbridge Island on April 13 to 15 for the purpose of giving talks on Mosquito Life History and Control Methods before the Bainbridge Island Community Club, Washington. Three-hundred Gambusia fish were also planted in several situations on the island at that time. Mr. Gjullin also made a short survey of mosquito species and their habitat at the point on April 26 to 28.

Mr. L. S. McLaine, Chief of the Division of Foreign Pests Suppression, Entomological Branch, was in the United States on official business, March 21–30. He spent two days in New York interviewing officers in charge of Port Inspection and Japanese beetle and European corn borer quarantine projects. The remainder of the time was spent in Washington, D. C., attending the hearings of the Plant Quarantine and Control Administration dealing with European corn borer, Japanese beetle, white pine blister rust and narcissus bulb quarantines. Many officials of the Bureau of Entomology, Plant Quarantine and Control Administration Board, were interviewed, with reference to entomological and plant inspection problems. The Canadian Legation was also visited.

The Annual Meetings of Entomologists

Headquarters for the holiday meetings of the American Association of Economic Entomologists and of the Entomological Society of America have been secured in the Chalfonte-Haddon Hall Hotel at Atlantic City, New Jersey. Meeting rooms for both societies and their sections, as well as the secretarial office and the exhibition

room, have been secured on the 13th floor of the Haddon Hall Hotel building. The American Association of Economic Entomologists will meet in the Viking Room which has a seating capacity of 368 persons. This room is 45.6 x 56.0 x 21.0 and is equipped with motion picture and stereopticon arrangements. The Entomological Society of America will meet in the Benjamin West room which has a seating capacity of 350 persons. It is 45.7 x 50.0 x 17.6 and is equipped with motion picture and stereopticon arrangements. Sections of the American Association of Economic Entomologists will meet in the Tower Room which can be used as a whole or divided into two or three parts as desired. The Green Room, which is 14.9 x 20.0, has been set aside as the secretarial room for the secretaries of the two societies. The Mandarin Room, which is 16.0 x 49.4 x 15.6, has been set aside as the exhibition room. All the above rooms are on the same floor and the members will find it easy to move from one to another.

Horticultural Inspection Notes

A conference of the bulb growers and inspectors of the States of Oregon and Washington was held at Tacoma, Wash., on April 10, 11, and 12, in connection with meetings of the Northwest Bulb Growers Association and the Northwest Florists Association.

The narcissus inspection records for the year 1931 have been published by the United States Department of Agriculture as circular PQCA-332. The circular shows that 374,265,694 narcissus bulbs were inspected during the past year.

California quarantine order No. 5 relating to the Mexican cotton boll weevil and the pink bollworm of cotton, was revised effective April 7, 1932, to add cottonseed cake and cottonseed meal to the commodities under restriction.

It was recently learned that alfalfa meal, when certified and shipped according to requirements, may now be shipped into Iowa from the alfalfa weevil infested areas at any time of the year. This quarantine revision became effective July 1, 1931.

The methods of using carbon disulphide emulsion for the field treatment of nursery plants to prevent Japanese beetle infestation were modified on April 15 in administrative instructions issued to inspectors by the Plant Quarantine and Control Administration as circular PQCA-333.

A modified interpretation of the relationship between State and Federal certification under the gipsy moth quarantine regulations was issued by Lee A. Strong, Chief of the Plant Quarantine and Control Administration, on May 10, as circular PQCA-334.

Mr. Phil S. Haner, Superintendent, Division of Plant Industry of the Illinois Department of Agriculture, was in Washington early in May conferring with representatives of the Federal Department of Agriculture on cooperative plant quarantine activities in Illinois.

The Solicitor of the Federal Department of Agriculture has prepared a synopsis of court decisions on the subject of plant quarantines and related problems. This synopsis is being distributed by the Department of Agriculture as mimeographed circular PQCA-335.

Arizona quarantine No. 21, relating to nut-tree insects, was revised on January 20, 1932, to provide for the entry, in limited quantities, of buds of hickory, pecan, and walnut, under fumigation and permit. Except for this provision, trees, cuttings, grafts, and scions of hickory, pecan, and walnut are prohibited entry, as heretofore, from all States except California.

The Secretary of Agriculture announced late in May that he had decided to continue the Federal quarantine governing the interstate shipment of narcissus bulbs, and an amendment to the regulations has been promulgated effective June 20, somewhat modifying the conditions under which Federal certification for such bulbs are issued to growers.

Messrs. R. A. Sheals and J. M. Corliss of the Plant Quarantine and Control Administration are spending the latter half of May and most of the month of June inspecting the environs of nurseries in New England and New York to determine their freedom from Ribes plants to the extent required by the white pine blister rust quarantine for shipment from that part of the country to lightly infected States.

Owing to the discoveries of the Mexican fruit worm infestations in the Lower Rio Grande Valley of Texas, reported in the last issue of the Journal, the shipping season for citrus fruit from that area was terminated at the close of March 25. The host-free period required by the State and Federal governments began on the morning of March 26. After that time no further permits were issued for fruit shipments from the Valley except for fruit which had been removed from the trees prior to March 26 and was held in cold storage.

The Federal pink bollworm quarantine regulations have been amended to authorize the use of a new form of roller equipment for the compression of cotton lint or linters as one of the conditions of certification under those regulations. The process was devised by commercial concerns for use at gins in order to reduce the bulk of cotton bales without incurring the expense involved in the present methods of high density compression. Experiments have shown that this equipment is apparently effective in the crushing of cotton seeds or pink bollworms which the bales may contain.

Mr. C. E. Cooley and Mr. Max Kisliuk, Jr., of the Plant Quarantine and Control Administration, who have been making a fruit fly survey in the West Indies and South America, returned to the United States on April 25, after an absence of approximately twelve months. During the year they visited all the larger West Indies (Antigua, Barbados, Dominica, Guadeloupe, Haiti, Jamaica, Martinique, Nassau, Nevis, St. Croix, St. John, St. Kitts, St. Lucia, St. Thomas, St. Vincent and Trinidad), and spent considerable time in Brazil, Uruguay, Peru, and Chile. Mr. Kisliuk has returned to his former post as Inspector in Charge at Philadelphia. Mr. Cooley will be stationed at Bellingham, Wash., and will have direct charge of that section of the Canadian border extending from the Pacific to the eastern boundary of the State of Montana.

The list of plants and plant products now subject to terminal inspection in Arkansas has been extended to include "Sweetpotato, onion, tomato, and cabbage, and other cruciferous plants, but excluding other herbaceous plants of all kinds, as well as seeds, bulbs, and roots. However, parcels of nursery stock (woody plants) originating within the State, which have an Arkansas permit or certificate attached, should NOT be sent for terminal inspection, nor should parcels of sweetpotato plants,

onion, tomato, cabbage, and other cruciferous plants originating outside of the State be sent for terminal inspection if an Arkansas permit is attached, nor should parcels of sweetpotato plants, originating within the State be sent for terminal inspection, even though no permit or certificate is attached."

Changes which became effective February 1, 1932, in the regulations of the Alabama State Board of Horticulture include: (1) Modifying the citrus canker regulations to prohibit the entry from Florida and Louisiana of citrus trees or parts thereof, and the seed and fruit of *Citrus trifoliata* (except fruit for food) and all other host plants of citrus canker. These materials may enter from other States only under permit. (2) Changing the areas designated as infested with the sweetpotato weevil to read as follows: "Alabama: That portion of Mobile County south of the north line of Township 2 South. Florida: Entire State. Louisiana: Entire State. Mississippi: Jackson, Harrison, Hancock and Pearl River Counties. Texas: Entire State." The areas released from quarantine under this order include Charlton County, Ga.; George County, Miss., and the entire State of Oklahoma. Florida was added to the recently designated area. (3) Restricting the importation of sweetpotato plants and tubers for propagation to those which have been grown under the Alabama requirements, including field, storage, and bed inspections, and certain sanitation precautions in bedding. These regulations are on account of the stem rot, black rot, and other diseases of the sweetpotato. (4) Eliminating nursery stock, fruit, and vegetables from the articles restricted on account of the alfalfa weevil and changing the areas designated as infested by the weevil. The new regulation prohibits as heretofore, the entry of hay and straw from the infested areas and requires certification of alfalfa meal entering at any time of the year.

Errata

Page 211, footnote 8, p. 211, April number, for Inc. = Incubation read Inc. = Incubator.

Pages 398 and 399, the illustrations are transferred, that on page 398 shows infestation in 1931 and that on page 399 the infestation in 1930 and not as stated in the legends beneath the illustrations.